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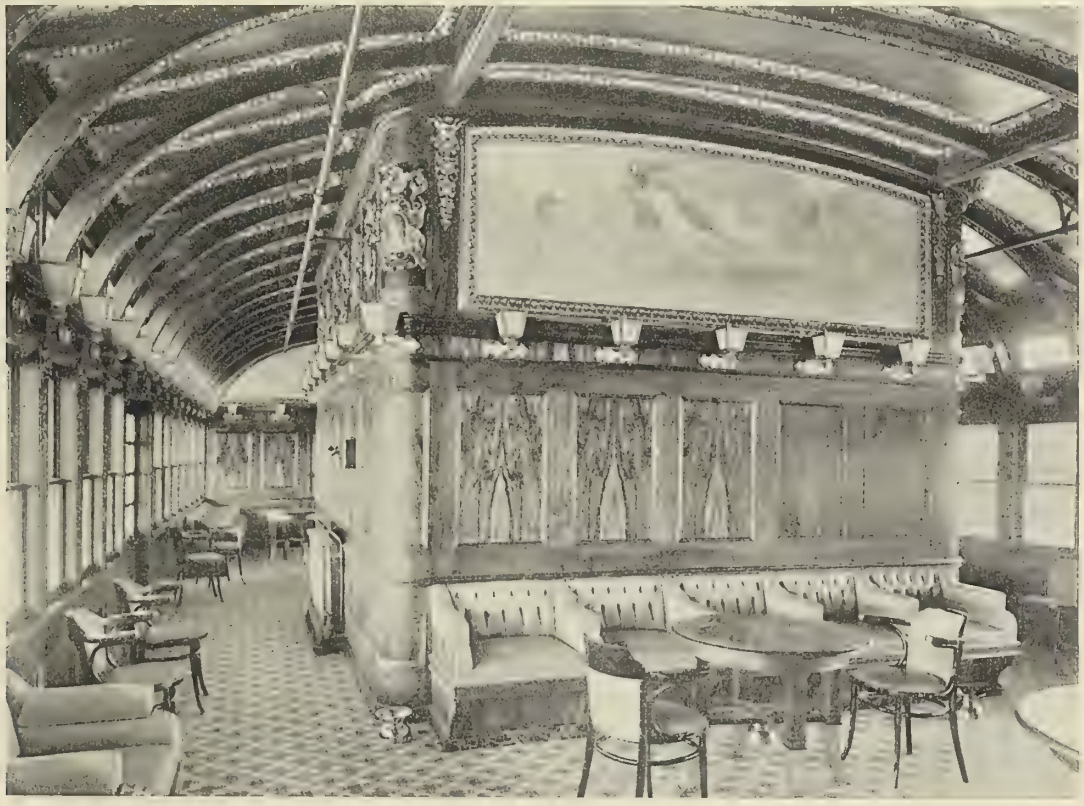
THE LAKE PASSENGER STEAMER CITY OF CLEVELAND.

The Detroit & Cleveland Navigation Company's new steamer, *City of Cleveland,* designed by Frank E. Kirby, naval architect, Detroit, and built by the Detroit Shipbuilding Company, is of the following dimensions:

Net tonnage	2,403; gross, 4,568
Length over all	404 feet.
Length on keel	390 feet.
Beam, hull	54 feet.
Beam over guards	92 feet 6 inches.
Depth	22 feet.



A CORNER OF THE CONVENTION HALL OR SMOKING ROOM ON THE CITY OF CLEVELAND.

(Six Photographs, Copyright, Detroit Publishing Company.)

The hull is constructed of mild steel, divided into ten compartments by watertight cross bulkheads. A double bottom is fitted, extending nearly the entire length and divided into compartments, which provides for the safety of the ship in event of grounding, and can be used to vary the trim and the draft by means of water ballast. Powerful pumps are fitted for this purpose. A steadying tank of 100 tons capacity is provided, to check the rolling in a heavy sea.

The shell plating includes a keel 36 inches by 30 pounds amidships, and nine strakes amidships on each side. Of the latter the garboard strake (*A*) and strake *I* measure 22½ pounds amidships and 16 pounds at the ends. Strakes *B, C* and *D* measure 21 and 16 pounds amidships and at the ends. Strake *E* is 25 and 16 pounds; *H* is 27½ and 16 pounds; *K* is 25 and 13 pounds; and *S* is 25 and 13 pounds, with a 25-pound doubling plate in way of shaft. The tank top plates measure 13 pounds in machinery space and 11 pounds forward and aft, with margin plates of 16 and 13 pounds respectively. The vertical center line keelson is 42 inches by 18 pounds. The frames above the double bottom consist of 6 by 3½-inch by 15-pound channels, with occasional web frames of 16 pound plate, fitted with double 5 by 3-inch by 9.8-pound angles at the inner edge. Between the double bottom and the main stringer plate are two fore-and-aft stringers, consisting in each case of a 6⅛ by 3⅝-inch by 21-pound Z-bar, backed up by an angle 3 by 3 inches by 7.2 pounds. The main stringer measures 45 pounds, decreased to 13 pounds at the ends, and is provided with a 30-pound doubling plate at the shaft.

The main deck beams are channels, 12 inches by 30 pounds for one-half length, decreased successively to 25 and 20½

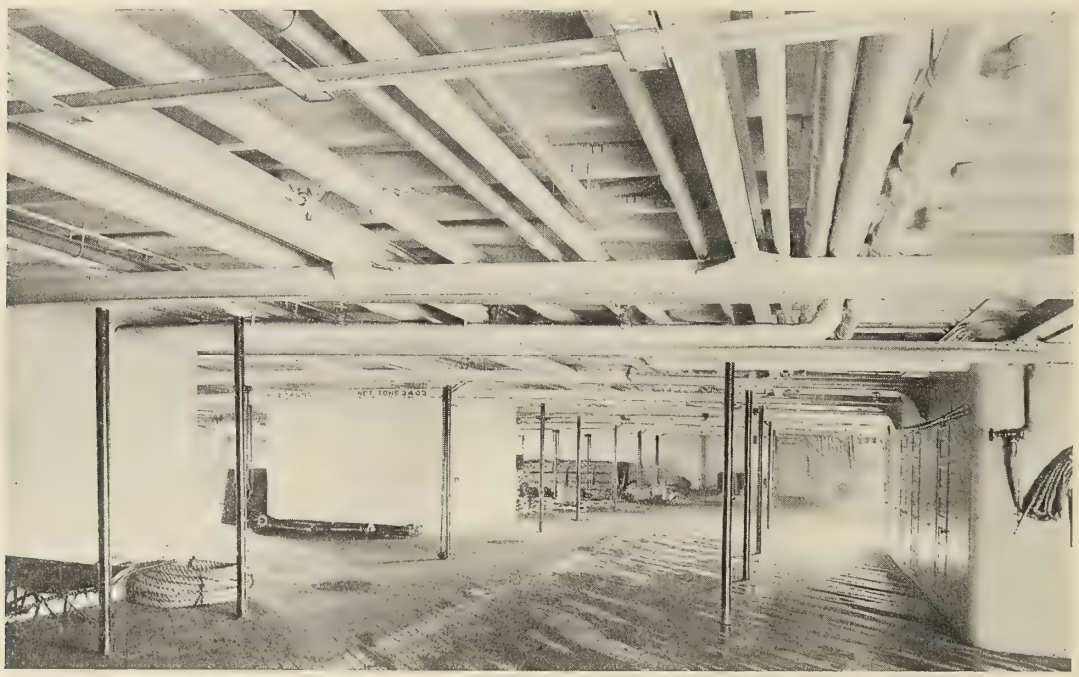
THE CITY OF CLEVELAND RUNNING AT FULL SPEED ON LAKE ERIE.

pounds. They are spaced 5 feet between centers. These beams are continued out under the guards by 6⅛ by 3⅝-inch by 21-pound Z-bars 5 feet apart, the latter being supported, as shown on midship section, by a cantilever frame work, the lower member of which is a T-bar, 4 by 4 inches by 13.7 pounds, while the other members are angles, 3 by 3 inches by 7.2 pounds. The promenade deck is supported by a frame of transverse I-bars, 15 feet apart and measuring 7 inches by 20 pounds, upon which are mounted, on each side of the center, five longitudinal I-bars of the same size, carried upon 13-pound rider plates. These longitudinals carry wooden deck beams measuring 4⅞ by 2⅞ inches, and spaced two feet between centers, upon which is laid the flooring. One photograph shows very clearly this arrangement. The deck beams above this are of wood, as indicated on the drawing of the midship section, page 378.

As shown in the longitudinal section, a very heavy framework is built up as a support for the paddle wheel shaft and to take the thrust of the engine. The plates are 16 pounds per square foot. Running fore and aft in the boiler room are auxiliary longitudinals, consisting of 15-inch channels, to compensate for the cutting of beams by the up-takes and funnels. The engine bedplate measures 25 feet 2 inches athwartship at the crank end, and 7 feet forward and aft on the inclined line. The cylinder foundation is upon a separate portion of the structure further aft.

The ship has seven decks; the main deck is of steel, sheathed with wood, to deaden the noise of handling cargo, for which the main portion forward of the machinery is used. The passenger entrance is located aft of the machinery, and forms a large lobby fitted with wide stairs extending to the upper decks, on which are located the staterooms, parlors and public rooms. Additional access is provided to all decks by a passenger elevator, with entrance off the lobby.

As shown in the longitudinal section, the central part of the orlop deck and hold is occupied by machinery. The forward end of the hold contains the dynamo room, fresh water tanks and space for stores; the after end contains the steering



BAGGAGE SPACE ON MAIN DECK. OVERHEAD IS SHOWN THE UNIQUE SYSTEM OF DECK BEAMS.

and ventilating engines, galley stores, fresh water tank and refrigerator. The entire forward end of the orlop deck is arranged for the crew, space being here provided for eighteen seamen, nine firemen, nine coal passers, thirteen in the engine room force, twelve galley men, thirty-five waiters, fifteen

THE GALLERY AFT, SHOWING STAIRS LEADING UP FROM LOBBY ON MAIN DECK.—A PARLOR SUITE.

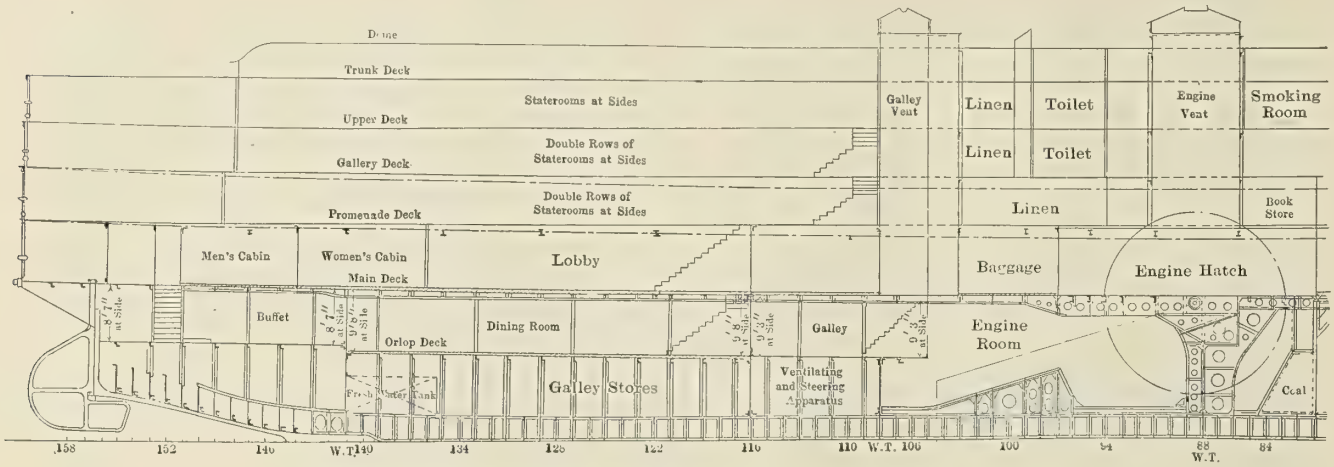
porters and twenty-four miscellaneous, making a total of one hundred and thirty-five. The after end of this deck is occupied by the galley, stretching from side to side of the ship; the pantries; the main dining room, which contains twelve round tables seating six each; two private dining rooms, seating respectively six and fourteen; and the buffet lunch room. These are constructed entirely of steel and made fireproof.

The main deck extends the full width of the ship over the guards. Nearly the entire portion is open for the stowage of baggage and freight. At the forward end is the windlass room for handling anchors, while provision is here made for carrying a few horses. Along the sides of the freight space are the paddle boxes, mess rooms and toilet rooms for various members of the crew. The after end is taken up with baggage rooms, the grand entrance lobby and two cabins. This deck includes quarters for seventeen of the crew, including the chief engineer and the purser.

The promenade and gallery decks are given up almost entirely to passenger accommodation. Down the center line are engine and boiler casings and ventilators, as well as staircases. On each side of the center line are three rows of staterooms. The two outer rows are arranged as "tandem" rooms, each having air and light from outside. The inner row obtains air by means of special ducts. The upper deck has a broad promenade space on the outside of the deck house,

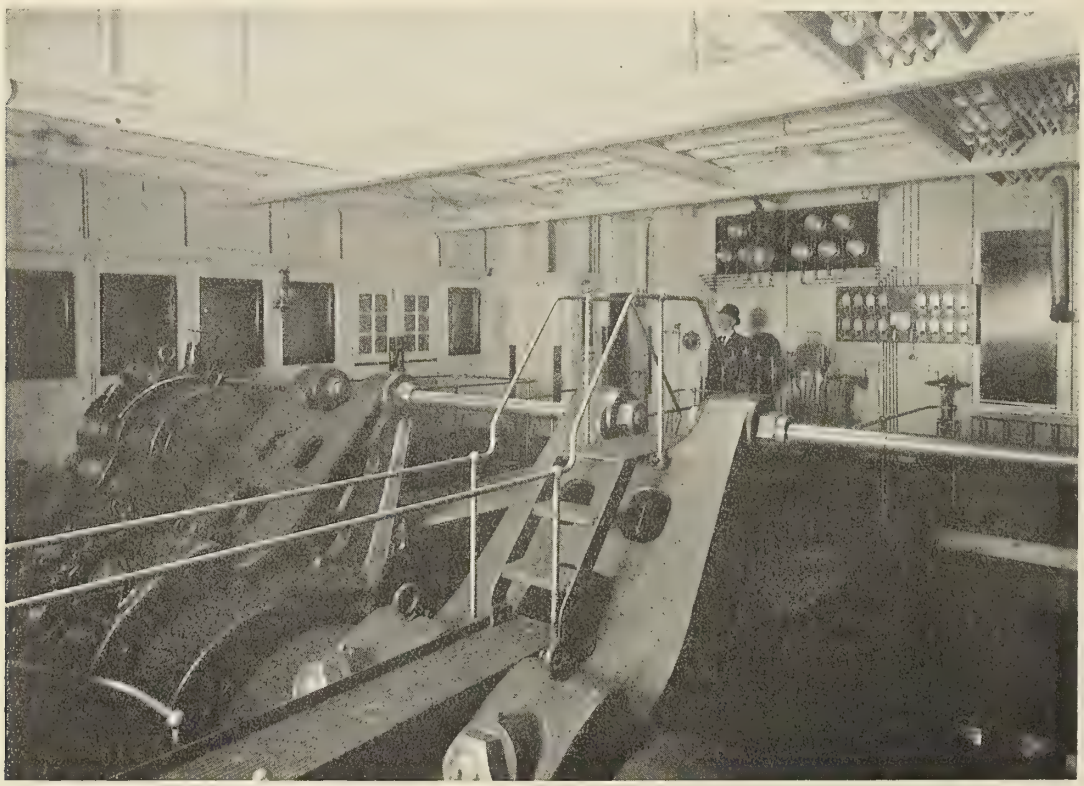
and, as a result, there is space for only a single row of staterooms. At the forward end of this deck are quarters for the navigating department, including the captain and ten others. Six musicians and the wireless telegraph operator (Clark's system) are also accommodated on this deck.

Aside from the cabins on the main deck, and the broad hallways and gallery, the only public gathering room is on the upper deck, surrounding the after funnel. This is known as the "Convention Hall," but is more properly the smoking room. It measures 51 feet in length by 23 feet in breadth, and is tastefully upholstered in leather. Among the 342 staterooms are twenty cabins de luxe, or "parlors," each with a private bath. Eight of these baths are tubs, while the other twelve are showers. These parlors, which are located on the promenade and gallery decks, are very daintily decorated. Six of them are provided with private balconies at the ship's side. The whole scheme of decoration throughout the vessel appears to tend towards simplicity. Beautiful examples of Circassian walnut quartering are seen in a number of the apartments; while the gallery is paneled in mahogany, with the style of Louis XVI. The decorative work was designed by Louis O. Keil, Detroit. The decorative ceiling and panel paintings are due to William de L. Dodge, New York. Above the main staircase in one of our illustrations will be seen a frog, the "patron saint" of the line. Since the photograph was taken, the ship's clock has been added to this frog, which greets everyone going up the main staircase from the entrance lobby.



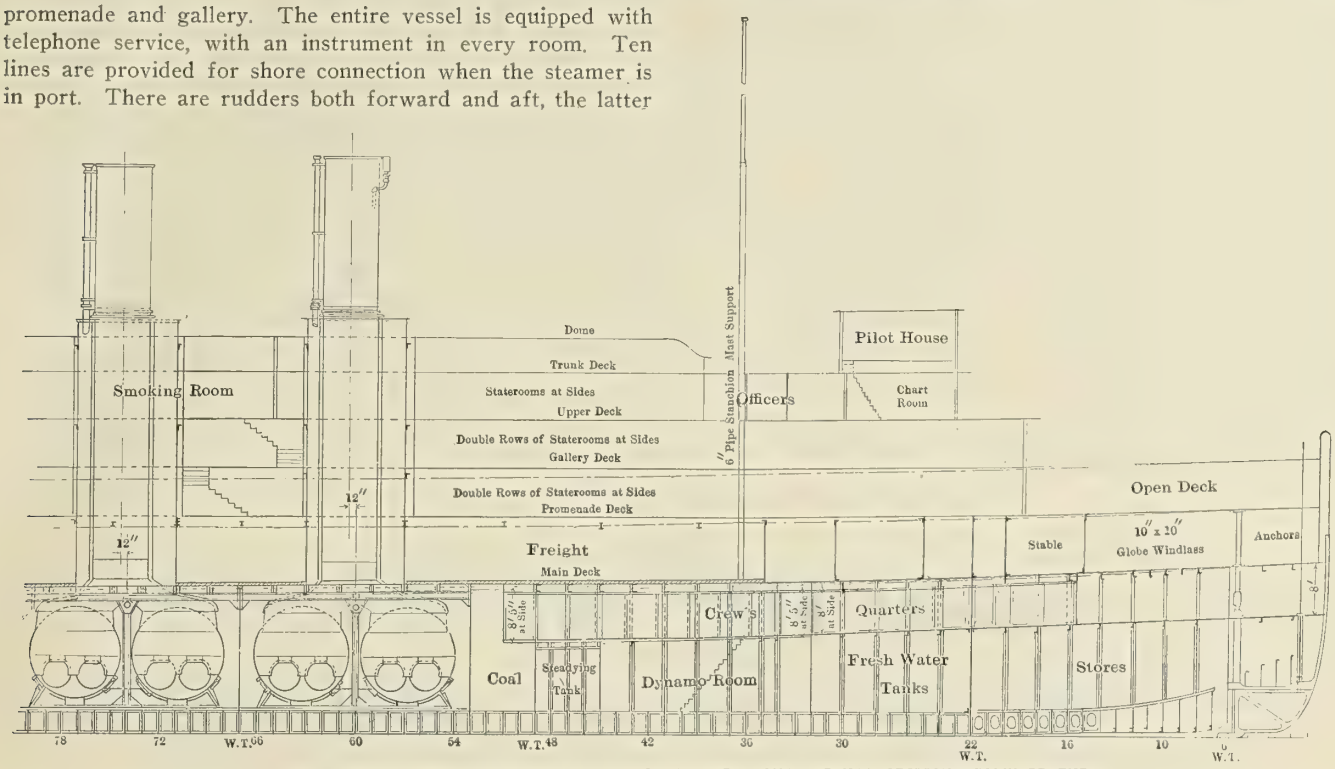
AFTER END—LONGITUDINAL SECTION—THE LAKE PASSENGER STEAMER CITY OF CLEVELAND.

The boat equipment consists of twelve lifeboats carried on the upper deck, eight being 24 feet long, two 20 feet and two 18 feet. The gallery extends through from this deck to the promenade deck, and by means of the main staircase aft, to the lobby on the main deck. An elevator runs from the orlop deck to the upper, passing successively through the main,



THE CRANK END OF THE MAIN ENGINE.

promenade and gallery. The entire vessel is equipped with telephone service, with an instrument in every room. Ten lines are provided for shore connection when the steamer is in port. There are rudders both forward and aft, the latter



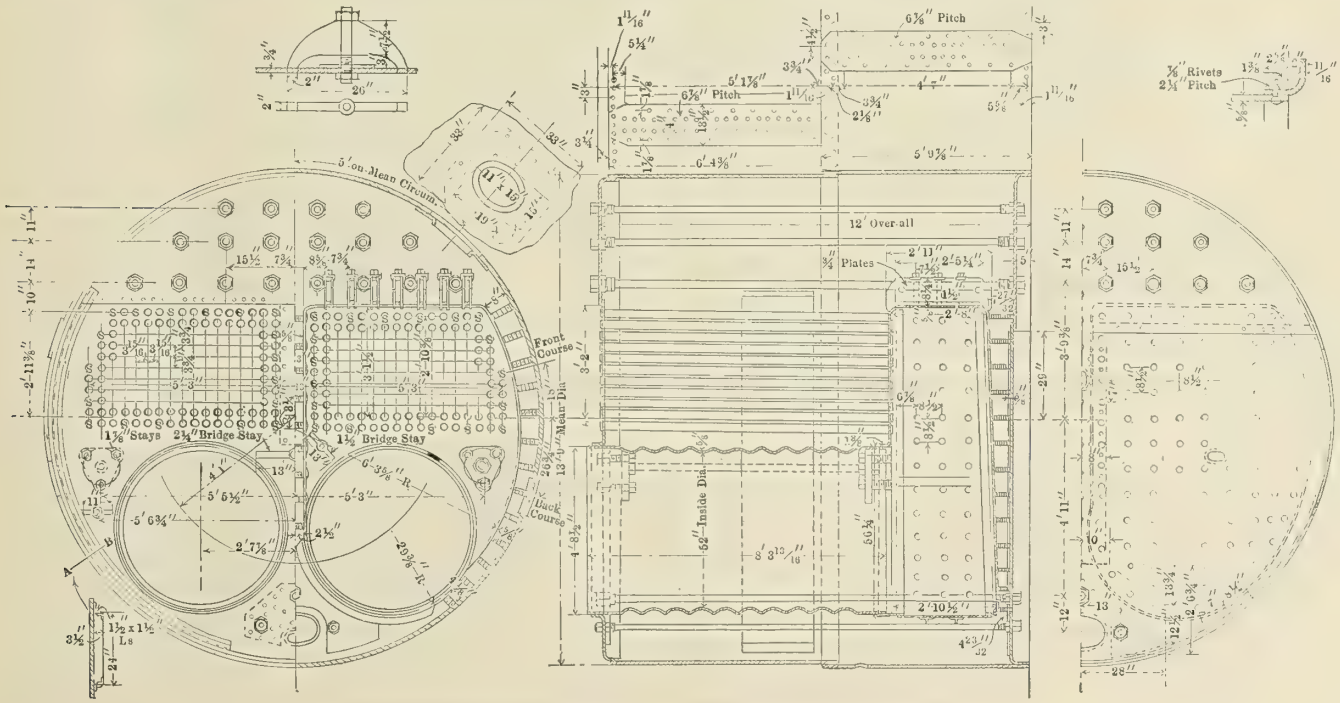
THE LAKE PASSENGER STEAMER CITY OF CLEVELAND—LONGITUDINAL SECTION—FORWARD END.

being balanced. The forward rudder is fitted to facilitate maneuvering in narrow waters. In addition to the usual steam steering engine fitted to both rudders, there is fitted Akers's auxiliary steam steerer to the stern rudder. This is arranged to be quickly connected from the pilot house, actual operation requiring about ten seconds.

For protection against fire, in addition to the usual equipment required by the United States steamboat laws, a complete sprinkler system is installed, together with a thermostat automatic alarm system in every room, which will give alarm in event of fire breaking out. All of the staterooms and crew's sleeping rooms are provided with fixed washstands, supplied with running water. The ship is ventilated throughout with cool, fresh air by the McCreery system. She is fitted with the Nicholson ship log.

A complete electric lighting plant is provided of 2,200 lights capacity, including a search light of 5,000 candlepower; and consists of three 30-kilowatt Western Electric Company generators, each driven by a Fuller single-acting Cornish cycle double-cylinder engine.

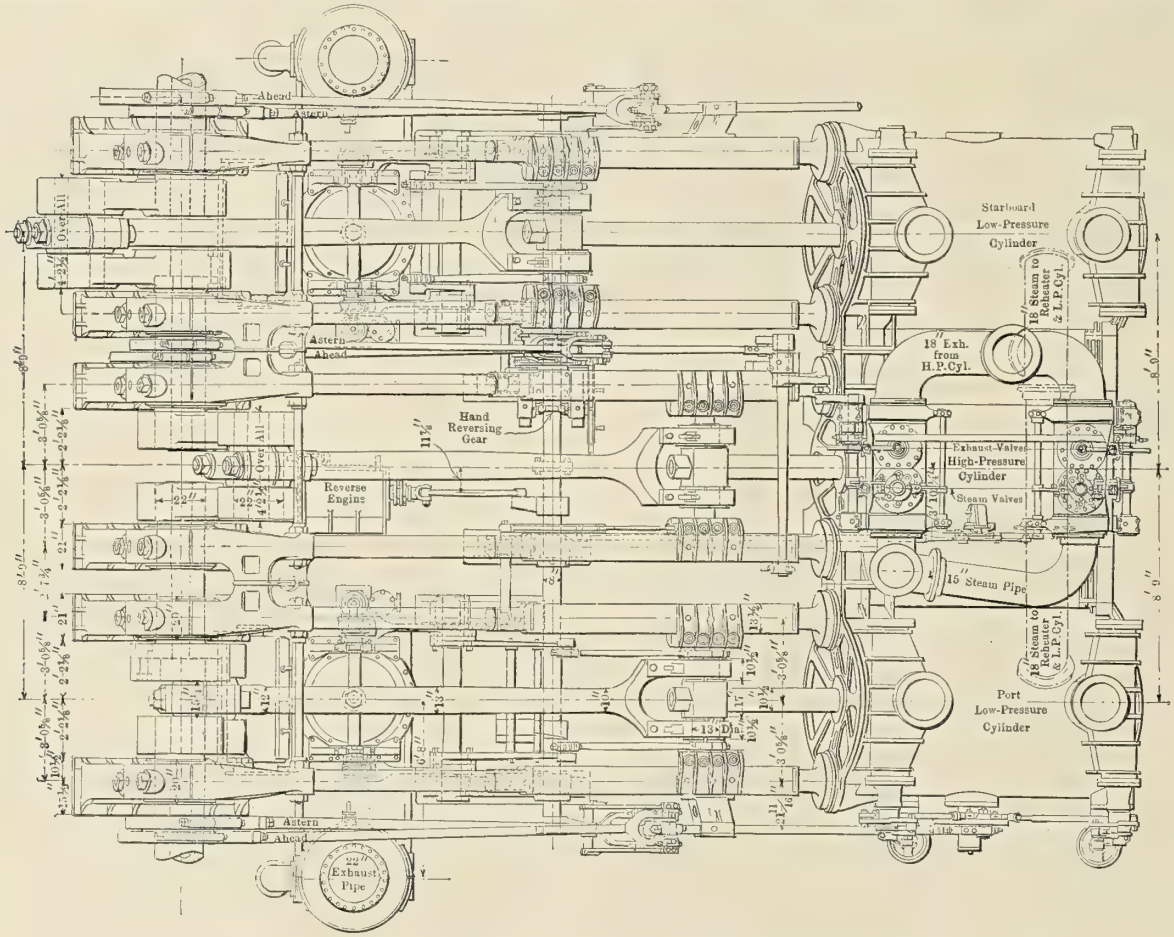
The propelling machinery, driving feathering paddle wheels, consists of an inclined three-cylinder compound engine; diameter of cylinders, high-pressure, 54 inches; two low-pressures, 82 inches each; stroke of pistons, 8 feet. The high-pressure



DETAILS OF CONSTRUCTION OF ONE OF THE EIGHT SINGLE-ENDED SCOTCH BOILERS.

engine is fitted with poppet valves and the Sickels cut-off gear; the low-pressure cylinders are fitted with Corliss valve gear. The main crank and paddle shafts are of steel, forged hollow, and rigidly coupled together in line across the ship. The crank pins are of steel, forged hollow. The paddle wheels are 29 inches in diameter, each having eleven paddles, 14 feet long by 4 feet 6 inches wide.

This type of engine was used because it was necessary that a type should be selected which would work with equal efficiency at high and low powers. This steamer is intended to make two trips a day, the day trip, in which time will be at a premium, to be at high speed, and the night trip conforming to the present schedule. It was also desirable that one-third of the total power should be developed in each cylinder, instead of having, as is usual in three-cylinder compound engines, the high-pressure cylinder developing almost



GENERAL PLAN OF THE THREE-CYLINDER COMPOUND INCLINED PROPELLING ENGINE.

one-half and the two lows not much over 25 percent each. This is what led to the adoption of the peculiar combination of valve gear, which is probably the first of its kind attempted in marine work. The result of this arrangement is that each cylinder has a very wide range of expansion, the cut-off point in each cylinder being adjustable from the starting platform at from one-fourth to five-eighths of the stroke. The pressure in the low-pressure receivers can thus be adjusted to divide the total power into thirds.

The inclination of the engine is 3.65 inches per foot. The main crank shaft and crank pins are hollow, measuring 22 inches in diameter, with an axial bore of 8½ inches. The connecting rods are 19 feet between centers, and measure 12 inches in diameter at the crank end, 13 inches at the center and 10 inches at the cross-head end. The piston rod is 10½ inches in diameter. The crank pins are 22 inches in diameter and 4 feet 2½ inches long over all. The cross-head pins are 13 inches in diameter and 38 inches long over all, with two bearings, each 10½ inches long. The reverse shaft has a diameter of 8 inches. The reversing engine is 20 by 30 inches, and is supplemented by hand reversing gear. The air pumps are 50 inches diameter by 40 inches stroke, while the bilge pumps, 7 by 40 inches, are also worked off the low-pressure cylinders.

The usual auxiliaries are fitted, which include one duplex fire pump, one duplex feed pump, one simplex compound feed pump, one duplex sanitary pump, one duplex fresh water pump. In addition, a compound centrifugal fire pump, driven by a Kerr turbine engine, is fitted for supplying water to the sprinkler system, which is automatically controlled.

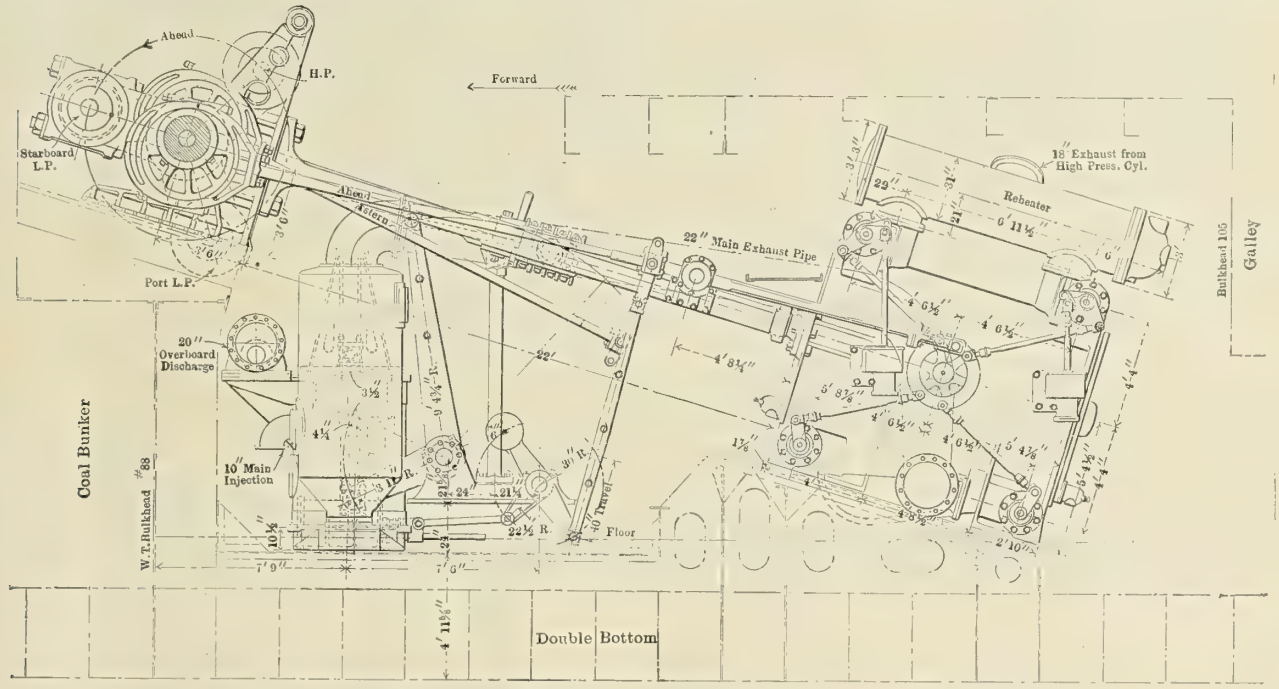
Eight cylindrical boilers are provided, located in two separate compartments. Their diameter is 13 feet 9 inches, and length 12 feet, each being provided with two Morison suspension furnaces, 52 inches in diameter. The working steam pressure is 160 pounds per square inch. The boilers are worked with the Howden hot-draft system. Two smokestacks are fitted.

Each boiler has a shell in two courses, each course being made of two plates 1 7/64 inches in thickness. The design of the seams shows a plate strength of 80.9 percent of the uncut plate, and a rivet strength of 80.35 percent. Details of riveting are shown on the drawing. In the upper part of the boiler are eighteen through steel stays in three rows; the upper row has stays measuring 2⅛ inches in the body and 2½ inches in the screw ends; the others are 2½ inches in the body and 2⅞ inches in the ends. In the region below the furnaces are three through stays measuring 2 and 2⅜ inches respectively, with bridge stays between the furnaces and the nests of tubes, measuring 2⅝ and 3 inches. The staybolts,

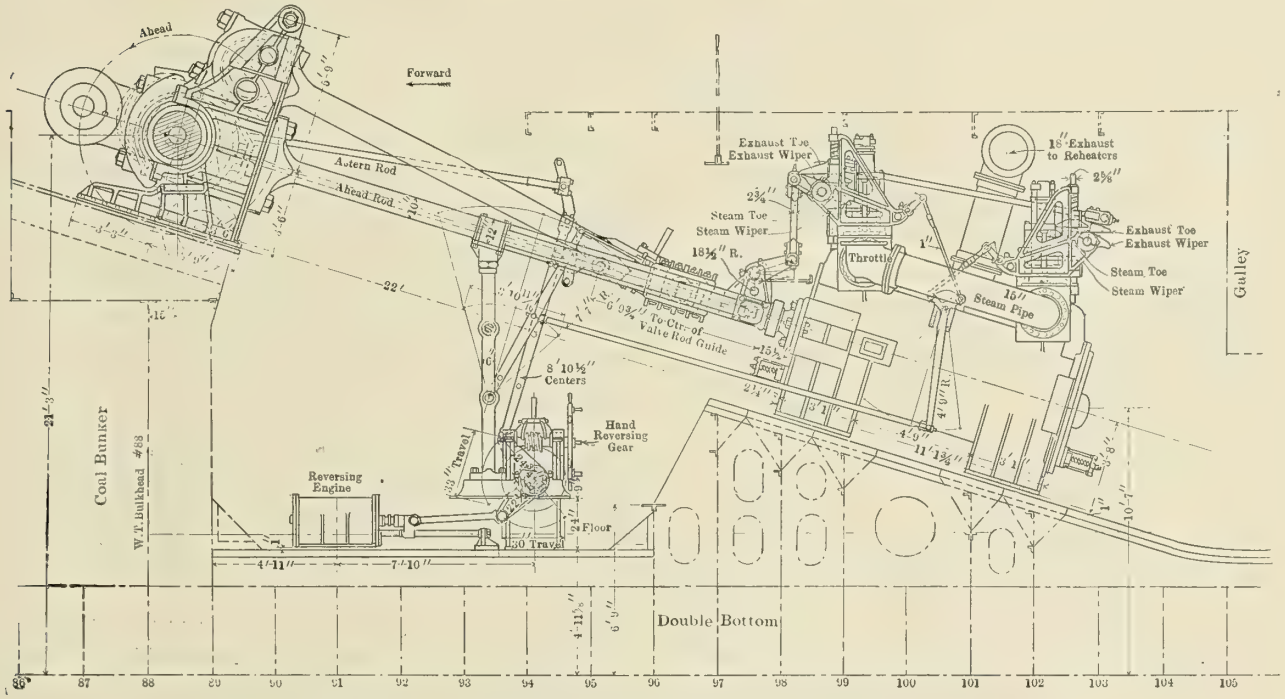
in connection with the combustion chamber, are 1½ inches in diameter, and have 10 threads per inch.

Each boiler contains 360 tubes, with an outside diameter of 2¾ inches. Of this number, 324 are ordinary tubes of No. 12 B. W. G.; the remaining 36 (marked "S") are stay tubes of No. 7 B. W. G. These latter are thickened at both ends to 3 inches and screwed through both tube sheets. The tube sheets are ¾ inch thick in front and 11/16 inch in back. The distance between sheets is 7 feet 11 inches. The back of the combustion chamber is ⅝ inch thick, while the boiler heads, which are flanged, are 1 3/64 inches.

A novel circulating device is arranged, as shown on the drawing. A sheet steel box, 24 by 3½ inches, made of 10-pound plate and angles 1½ by 1½ inches, is attached to the shell of the boiler on each side about midway between the tube sheets. This box starts at the bottom of the boiler and extends to about the location of the waterline. The idea is for water to flow down through these boxes, and thus create a better circulation than would naturally exist through the nest of tubes, unaided by such a device.



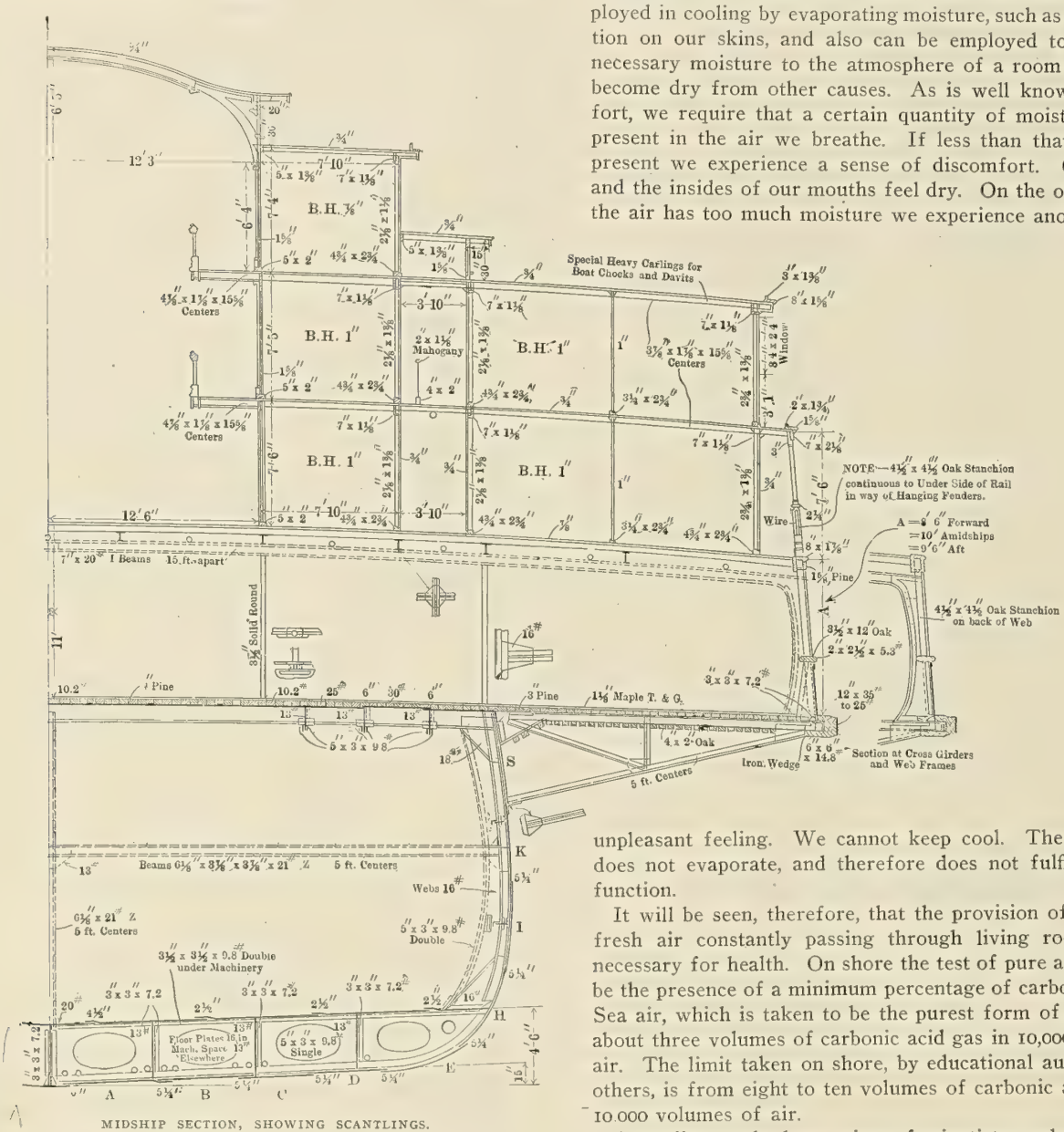
ELEVATION OF THE PORT LOW-PRESSURE ENGINE, SHOWING ARRANGEMENT OF CORLISS VALVE GEAR.



ELEVATION FROM PORT SIDE OF THE HIGH-PRESSURE ENGINE, SHOWING SICKELS CUT-OFF VALVE GEAR.

A condition of the contract for the steamer required her to make an average speed of 20 statute miles per hour over a course on Lake Erie, between South East Shoal Lightship and Long Point, distance 133¼ miles, depth of water, 12 to

15 fathoms. The trial was made April 27, and the designed speed was obtained with an average horsepower of 5,717; revolutions, 27.6 per minute; maximum power, 6,622, with 29 revolutions. Since that run revolutions have been increased to 30 under the same conditions.



MIDSHIP SECTION, SHOWING SCANTLINGS.

THE HEATING AND VENTILATING OF SHIPS.

BY SYDNEY F. WALKER, M. I. E. E.

VENTILATION.

In the preceding sections, as explained, the writer has dealt with heating alone, but he has mentioned, from time to time, that heating and ventilating are very closely allied, that you cannot warm any room, for instance, or have any source of heat present in any room, without producing air currents, which necessarily ventilate to a greater or less extent. He now proposes to discuss the question of ventilation by itself, having already shown how the two can be worked together.

Ventilation, as explained in the opening article of this series, is to the atmosphere of any room, or any space in which men have to work or live, what water is to dirt. Atmospheric air has the property of carrying off noxious gases, such as the carbonic acid gas that is given off at each breath by the lungs of men and animals, the exhalations that are constantly being given off from the skin of everyone, the microbes, bacilli, and even the dust that is always present. If a continuous current of air is provided, passing through living rooms, etc., the whole of these should be carried harmlessly away.

In addition to the above, atmospheric air has the property of absorbing the vapor of water, and can therefore be employed in cooling by evaporating moisture, such as the perspiration on our skins, and also can be employed to deliver the necessary moisture to the atmosphere of a room when it has become dry from other causes. As is well known, for comfort, we require that a certain quantity of moisture shall be present in the air we breathe. If less than that quantity is present we experience a sense of discomfort. Our tongues and the insides of our mouths feel dry. On the other hand, if the air has too much moisture we experience another kind of unpleasant feeling. We cannot keep cool. The perspiration does not evaporate, and therefore does not fulfil its natural function.

It will be seen, therefore, that the provision of a supply of fresh air constantly passing through living rooms, etc., is necessary for health. On shore the test of pure air is taken to be the presence of a minimum percentage of carbonic acid gas. Sea air, which is taken to be the purest form of air, contains about three volumes of carbonic acid gas in 10,000 volumes of air. The limit taken on shore, by educational authorities and others, is from eight to ten volumes of carbonic acid in every 10,000 volumes of air.

According to the latest view of scientists, carbonic acid gas has been made more or less of a bogey. From tests that have been made it has been shown that human beings can live, without inconvenience, in an atmosphere containing a very much higher percentage of carbonic acid than that given above. On the other hand, however, it appears to be quite correct in the majority of cases to take the percentage of carbonic acid present in the atmosphere, which can be tested, as a guide for the purity of the atmosphere, with reference to the other matters, organic impurities, etc., that have been mentioned above. But this is not always strictly correct. In the case, for instance, of lavatories, the carbonic acid present may be comparatively small, while the organic matters, as evidenced by the smell, may be comparatively large. The special case of lavatories is dealt with later on.

Ventilation is known as natural or mechanical, according to whether it is left to take care of itself or is more or less controlled. Mechanical ventilation is also sometimes known as either "plenum" or "vacuum." Marine engineers have exactly

the same division in the matter of their furnace draft, natural ventilation corresponding roughly to natural draft and mechanical ventilation to forced or induced draft. Plenum ventilation, which has already been described when dealing with methods of heating air, corresponds to forced draft and vacuum ventilation to induced draft. Natural ventilation can perhaps hardly be said to correspond to chimney draft. It corresponds really to a condition that would be present if there were no chimney.

Perhaps the different methods of ventilation, and the principles of ventilation itself, will be best understood by a reference to the case where it is of the greatest importance, viz.: in coal mining. In a number of coal mines, it will be remembered, as the coal is removed from its bed, gases are given off, which, if mixed with air in certain proportions, will explode and do great damage if a light is presented to them. The explosive mixture is between 5 and 15 percent of the gas in the atmosphere of the mine. When the gas is present in a greater quantity than 15 percent it will not explode, because it cannot contain sufficient oxygen for combination. On the other hand, when the quantity present is less than 5 percent it will not explode, because it is too much diluted with the nitrogen of the atmosphere. These figures apply also to dangers from the vapor of petroleum in tank ships. In the United Kingdom, therefore, successive acts of Parliament have decreed that a certain volume of air shall be passed through all coal mine workings, the volume being sufficient to very quickly dilute, below the explosion point, any gas which comes away. Probably this illustrates, as well as anything, the cleansing action of atmospheric air.

The majority of mines in the United Kingdom, and a large number in the United States, lie wholly below ground, and are reached by two vertical shafts, one of which conveys fresh air to the mine and the other carries off the vitiated air from the workings. From the two shafts, which are named respectively "down cast" and "up cast," two main roads run into the mine, called respectively the "in-take," which extends from the down cast, and which carries the fresh air into the workings, and the "return," which carries the vitiated air from the workings to the up cast. Roadways, or air passages, connect the two main roads in such a manner that there is a constant current of air passing across all working faces from the in-take to the return.

In the early days of coal mining, what would now be termed natural ventilation ruled. The air current was left to take care of itself. Usually the warm, moist, vitiated atmosphere from the workings found its way to one of the shafts, and being lighter than the column of air in the other shaft a certain difference of air pressure was set up between the two, which caused a certain variable and uncertain circulation of air through the workings. It was no uncommon thing in those days for the direction of the ventilating air current to be reversed. In those days also, occasionally, there was only one shaft. It was sometimes divided by brattice cloth into two, the vitiated air finding its way up one half and the fresh air moving down the other half. In some cases even this division was not provided, and the air in those cases formed a division of its own, the warmed air escaping up one side of the shaft while the cold air passed down the other side. The state of the coal mines in those days illustrates very forcibly what natural ventilation really means. Practically there was very little ventilation at all. Any change in the temperature of the atmosphere outside might stop the course of the ventilating current entirely.

The first improvement was the provision of a furnace in the neighborhood of the bottom of the up-cast shaft, which, by providing a column of hot air in that shaft, created what mining engineers call a motive column, by means of which the air from the outside atmosphere passed down the down-cast shaft and through the workings to the up-cast. In most modern coal mines the furnace has given way to the fan, which is usually placed at the top of the up-cast pit. It is placed there principally because the up-cast pit was covered in when furnace ventilation ruled, to prevent the ingress of the colder air to the shaft, thereby neutralizing the effect of the furnace, and it was simpler to make use of the existing arrangements and to adopt the fan to them than to make new arrangements. In a few cases, however, the fan is fixed at the top of the down-cast shaft, and forces air into the mine, the vitiated air, as before, finding its way out through the up-cast shaft. In a few cases, also, the fan at the top of the pit is assisted by fans at the level of some of the seams that are worked from the pit, and also by fans placed in different positions in the workings, to direct the currents of air over particular portions of the working faces, etc.

Marine engineers will recognize a practical counterpart to their own arrangement for supplying their boiler furnaces with air. Furnace ventilation of a mine corresponds to the ordinary chimney draft of a boiler, and fan ventilation corresponds to forced or induced draft, according to whether a pressure or exhaust fan is employed.

The writer would call attention to one very striking feature in connection with mine ventilation, which he thinks will assist marine engineers to follow the work that has been done in the ventilation of buildings, ships, etc. It will be noticed that the shafts, the roads, together with a fan or furnace, form a complete circuit, corresponding exactly to an electric circuit. The shafts and the main roads correspond to the main distributing cables of a two-wire electrical supply service. The branch roads, connecting the working faces with the main roads, correspond to the branch cables or wires connecting lamps or motors to the main supply cables. The furnace, where one is employed, corresponds to a battery, where one is used to supply current, and the fan corresponds to an electric generator.

The correspondence is even closer than this. Just as successive coils of wire, passing through the magnetic field of a dynamo machine, produce successive increments of electrical pressure, so the passage of the successive blades of a fan produce successive increments of air pressure. Further, air encounters resistance in its passage through a mine, just as an electric current encounters resistance in its passage through a conductor, and the resistance in both cases varies directly as the length and inversely as the sectional area. Thus, the greater the length of the main roads of a mine through which the air current has to pass, the greater is the resistance offered to its passage, and the greater must be the air pressure, measured in water gage, to overcome it. Also, the larger the air passages the less is the resistance offered.

The latter statement will appear at first sight to be incorrect, inasmuch as the resistance to the passage of air through any roadway, pipe or duct depends directly upon the friction of the air against the sides of the duct, roadway, etc., and evidently the larger surface of the larger road will create more friction than a smaller surface of a smaller road. But there is another factor in the problem in connection with air. The resistance offered to its passage varies as the square of its velocity, and its velocity increases with a given air delivery as the area of the road or duct through which it passes is reduced; and, therefore, though the increase of the size of the road or duct increases the friction offered by the surface, the total resistance is considerably lessened, because the velocity is also lessened.

And all this applies to the ventilation of buildings, of ships, etc. Modern ships in particular correspond in a great many respects to the modern coal mine in the matter of ventilation. The modern ship is divided into compartments by athwartship bulkheads, and in the case of very large ships like the

Lusitania by fore-and-aft bulkheads. It thus becomes necessary to deal with each compartment, from the topmost deck, downwards, by itself. In the *Lusitania* two compartments that are abreast sometimes communicate by watertight doors, as in the case of the electrical engine room, and while the doors are open they can be dealt with as one; but the separate compartments as a rule have to be dealt with separately, and, just as with a coal mine, all the fresh air has to be brought from the surface, in this case the deck, and the vitiated air must be carried off, either on the same deck or at some point where it will not mingle with the air that is going down below.

The ventilation of ships has gone through very much the same course of development as the ventilation of mines. In the early days it was left to take care of itself, open hatches and open ports being trusted to do the work. Later on the equivalent of furnace ventilation was established, ducts being led into the holds, mess rooms, saloons, etc., the other ends of the ducts being carried to the neighborhood of the funnel, and the circulation of the air being set up by the heated column of air produced by the hot gases in the funnel, fresh air being allowed to enter by cowls and other arrangements provided for them.

In the early days of heating and ventilating of ships compressed air was used in some cases to provide suction of the air out of the hold and between decks on the well-known injector principle, fresh air being allowed to find its way down below by air inlets something on the lines of the cowls that have been mentioned; but all these systems have given way to the use of the fan, since electricity has been established on board ship and the convenience of the electrically-driven fan has been appreciated.

Another point of importance should be noted here. It is absolutely necessary that there shall be a complete circuit wherever ventilation is to be carried on. In the case of the coal mine, the circuit is from the atmosphere, say at the entrance to the down-cast shaft, through the down-cast shaft, the in-take airway, the branch roads, the return airway, the up-cast shaft to the atmosphere again. In the case of the air supply of a boiler furnace, it will be remembered, there is the same circuit. From the atmosphere, by various passages to the stoke hole, through the ashpit, the fire bars, the fuel, the fire tubes, the up-take and the funnel to the atmosphere again. Just as with an electric circuit, if the circuit is broken, or if the passage of the current is cut off, the working of the apparatus the current operates is also stopped; so if the ventilating circuit is broken at any point, if the passage of the air current is cut off by any obstruction, the working of the ventilating air current is also stopped. Further, just as with an electric circuit, if a resistance is introduced into the path of the current the strength of the current itself is reduced with any given pressure, so if any obstruction is introduced into the path of the air current, whether for ventilation or for a boiler furnace, the strength of the air current, with any given air pressure, is reduced.

It was mentioned above that the resistance offered to the air current depends directly upon the length of the path through which the air has to move, and inversely as the sectional area of the path. In other words, the smaller the duct through which the air supply is carried the greater is the resistance offered to its passage, and this means that the greater is the pressure which has to be employed in delivering the air current, and the greater the velocity of the air current itself. In this matter the ventilation of ships is at a disadvantage compared with the ventilation of buildings on shore and with that of mines, though the advantage is not often taken full advantage of on shore.

For perfect ventilation, and for the avoidance of what is known as a draft, the air should circulate with a very low velocity, from 3 to 5 feet per second, but in order to do this the ducts through which it circulates must be large, and on board ship, even in the very largest liners, it is not possible to allow a sufficient space; as usual, a compromise has to be effected. The ducts have to be made as large as the other requirements of the ship will allow, their length as short as can be conveniently arranged, and the requisite current of air must be made up by increasing the velocity as required.

A striking instance of what may be done by the provision of large ducts will probably make the matter clear. At the Birmingham General Hospital, where the plenum system has been carried out very carefully under the direction of an able architect, it is not possible to feel any draft anywhere. The whole of the building is subject to a very gentle air current, and as one passes from corridor to ward, or ward to corridor, one is absolutely unconscious of any change. Those who have visited the usual run of hospitals, where the windows are kept wide open on the stairs, while the wards are kept warm in winter, will have sometimes a painful experience of the great change in the temperature between a ward and the landing outside.

Further, at this hospital, the smells that are so often in evidence, such as those of dinner, of medicines, etc., are absolutely unknown. Everyone will be familiar with the unpleasant smell there always is about a restaurant immediately after dinner, and usually also in the neighborhood of the wards of a hospital while dinner is going on and immediately afterwards. One can frequently tell, a little way off, if cabbage is an article of diet, and so on. At the Birmingham General Hospital there is no sign of anything of the kind. The ventilating air current carries off all odors, just as the ventilating current of a coal mine carries off the explosive gases. And this effect is produced with the expenditure of a very small amount of power—20 horsepower only—and with an air pressure of only 1/20-inch water gage. Marine engineers hardly need reminding how very small a pressure this is.

At Birmingham the result is produced by very large ducts. In the main duct a dozen men can stand abreast, and there is almost head room for a man to stand on another man's shoulders to reach the ceiling. The branch ducts are in proportion, and the result is as described. As against this the ventilating air current of the majority of coal mines, though the airways in the best of them are wide and high, is very powerful indeed, and it is a serious source of danger to working miners coming from the coal face, where, in spite of the air current, the temperature in deep mines is very high indeed, and where their physical exertion causes profuse perspiration, for them to come out into the cold air current of the main roads.

As explained above, it is not possible to provide large ducts, even in the largest ships, for ventilating air currents; but, on the other hand, the lengths of the ducts, even those leading to the lower decks, is not great.

As mentioned above, the ventilation of ships has settled down to the motion of the air by fans just as has the ventilation of coal mines, and just as the tendency of modern boiler work is to provide either forced or induced draft by the aid of fans. As with coal mines, also, and as with boiler furnaces, the air may be forced into the space to be ventilated by a pressure fan, the vitiated air being allowed to escape by any convenient outlet, or the air may be exhausted from the space to be ventilated by a suction fan, and fresh air drawn into the space through any convenient inlet. The one thing to remember in all cases where efficient ventilation is sought is that there must be an inlet and an outlet, and that the same quantity of air which passes in must pass out.

A point that should be noted here is that where the space to be ventilated is also heated, whether the air is heated artificially on its way to the space, or whether it is heated in the space, either artificially or by the presence of men or

animals in the space, the volume of air passing out will usually be greater than that passing in, and therefore the outlets should have a larger area than the inlets. The problem in this case is the same as that in connection with both mine ventilation and the supply of air to a furnace. The fan supplying induced draft, it will be remembered, must be larger, in the sense that it will allow a larger volume to pass through it than the fan required for forced draft, because the volume of the hot gases is larger than the volume of the air that is to be delivered to the fan. In the case of the ventilation of saloons, cabins, etc., the difference in volume of the air will usually not be great, but the caution given above should be remembered, in order that those who are responsible for the designing of systems of ventilation for ship-board work should be careful not to make the outlets smaller than the inlets. Making either an inlet or an outlet small throttles the passage of the air through it, increases the pressure at which the air has to be driven through the space to be ventilated, and increases the tendency to drafts.

For ventilation, therefore, whether of the between decks where cattle are carried, the large living spaces where steerage passengers are carried, or the saloons, staterooms, or officers' cabins, the same principle holds good. Air must be brought from the deck to the space to be ventilated, and the vitiated air must be allowed to find its way back to the deck or to the outside of the ship. In some of the White Star liners air is brought down from the deck under pressure, is directed through ducts into the staterooms, and is allowed to escape through the ports of the staterooms, saloons, etc., when the ports are open, and when the ports are not open the air escapes by a duct provided specially for it, opening into the the ship on the inside, and opening into the atmosphere on the outside of the ship, but protected by a valve on the outside, which is open when the sea does not rise to it, but which closes automatically when the ship rolls and dips that end of the duct or if the sea washes up to it. The writer understands that this method is giving way to the system that has been worked out by the Thermotank Company, in which all air is taken from the deck and returned to the deck.

In the case of cabins, staterooms, etc., opening to the atmosphere, such as those on the upper decks, boat decks, etc., where there are any, the system of ventilation can be modified. Air may be taken in or expelled from the side of the cabin, but provision must be made for the exit of the air. In the *Lusitania,* in some of the cabins on the upper deck, an adjustable inlet is provided for the air in the side of the cabin, and it is exhausted by a duct leading to the boat deck, a small electrically-driven fan providing motive power for the air when required.

In some of the cabins on the boat deck of one of the White Star liners the writer noticed another ingenious method of ventilation, based upon the injector principle. A T-shaped pipe was fixed on the side of the cabin, the central portion, the stem of the T, projecting into the cabin, and the top, or cross, of the T being arranged fore and aft outside of the cabin. As the ship goes through the water air rushes through the portion of the pipe outside of the cabin, and draws air through the connecting piece leading to the cabin, causing a current of air to pass out of the cabin, through the after portion of the fore-and-aft piece. This would probably make a very efficient ventilating arrangement, but it must again be remembered that some method of providing the inlet air must be arranged or the ventilation cannot go on. The inlet air may be provided by a protected duct leading to the deck above, or in any other convenient way.

VENTILATION AND HEATING AND COOLING.

The connection between heating and ventilating has already been explained, and that between cooling and ventilating to a certain extent. It will be understood, from what has been said, that once possession is obtained of a current of air passing continuously through a room, a saloon, mess room, cabin, etc., it can be employed for warming the room, cooling it, providing it with moisture, or reducing the moisture present by merely placing the heating, cooling, humidifying or drying apparatus in the path of the air current, and by properly proportioning the heat supplied, the heat extracted, or the moisture supplied or extracted, to the requirements of those occupying the room. Also, it will be understood that, with properly arranged apparatus, it should be possible to vary the heating, cooling or moisture at will in each compartment dealt with.

VENTILATION OF LAVATORIES AND CATTLE SPACES

The ventilation of lavatories and between the decks where cattle are carried presents some difficult problems. So far as the writer is aware the between decks for cattle have not been subject to any special method of ventilation, but lavatories

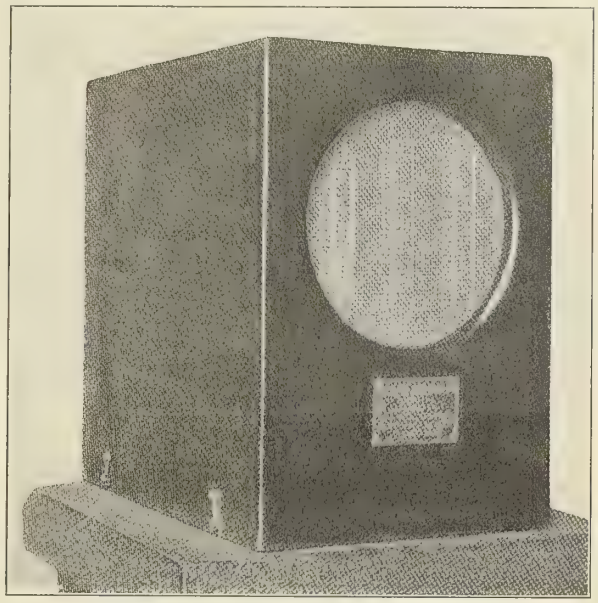


FIG. 66.—SIMPLEX OZONE PRODUCER, EXTERNAL VIEW.

have, and in his opinion the between decks for cattle, and even in some cases the steerage quarters, might with advantage be subject to the apparatus to be described. The difficulty in the matter of ventilation in these cases is the effluvia that is too often present, and that even a powerful ventilating current sometimes fails to get rid of.

The remedy appears to be the addition of ozone-making apparatus to the ordinary ventilating current. Ozone, it will be remembered, is oxidized oxygen. Its chemical symbol is O_3; oxygen in the ordinary way usually combining only as O_2. Ozone is the great vivifying agent that is so much sought after by invalids who take sea passages and who go to the seaside. It has a very peculiar and by no means a pleasant odor. It may be smelt, especially in the early morning, on open hill sides, and on the decks of ships at sea, and again at the seaside, in particular, close down to the water's edge.

It is oxygen in a very powerful condition, and its office is to oxidize, that is to say, to burn up the microbes, bacilli, etc., which produce the offensive effluvia and which will cause disease if allowed to remain. Ozone is produced by electricity. It may always be smelt by those who know its characteristic odor after a thunder storm. It is created in fairly considerable quantities by every flash of lightning, and by the silent discharges which take place during thunder storms which do not give rise to lightning. It is

created industrially by the aid of high-tension alternating currents, combined with what are called electrical condensers. The electrical condenser is quite different from the steam condenser. Every electric cable is an electrical condenser. Whenever two conductors are close together, but separated by an insulator, an electrical condenser is formed by them, and

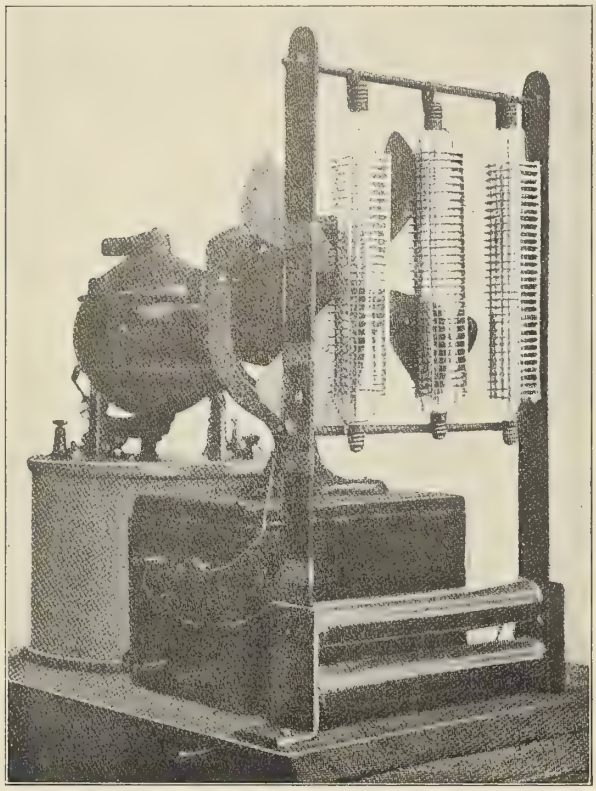


FIG. 67.—SIMPLEX OZONE PRODUCER, AS SUPPLIED TO WHITE STAR STEAMERS BY THOMAS ANDERSON.

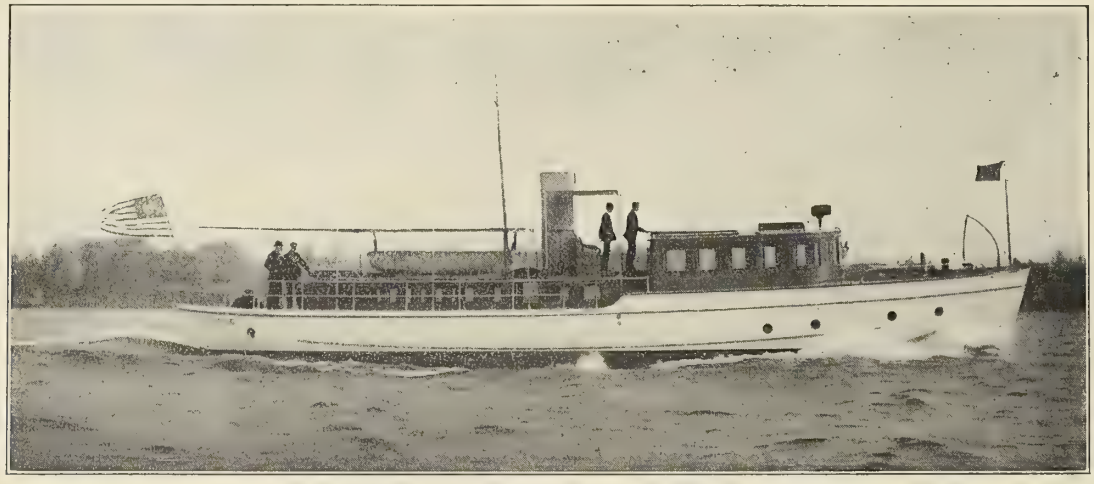
if an electric current is delivered to one conductor a charge of electricity is delivered to and absorbed by the insulating substance separating the two conductors.

For ozone-making apparatus condensers are formed sometimes of glass tubes with conductors arranged inside and out, and sometimes of glass plates, with sheets of metal foil between. In the Anderson apparatus, which is illustrated in Figs. 66 and 67, the condenser consists of the glass tubes shown, with conductors in the form of coils of wire on the outside and other conductors on the inside. In all electrical condensers one of the conductors is connected to earth, in this case to the body of the ship, and a high-tension alternating current is delivered to the other conductor. The condenser is arranged to be placed in the path of an air current, and the constant charge and discharge of the electrical condenser, produced by the passage of the alternating current, converts ozone into the oxygen of the air passing through it, the ozonized air being then delivered wherever it is required.

The high-tension current is produced on shore by the alternating currents of the ordinary town supply service, raised to very high tension—several thousand volts—by means of stationary transformers, similar to those that are used for the distribution of high-tension currents. Up to the present, so far as the writer is aware, alternating currents have not been employed on board ship, and therefore some arrangement is necessary for converting the continuous currents to alternating. This may be done by means of small motor generators, consisting of two distinct machines, a continuous-current motor taking current from the lighting or power service of the ship, and an alternating-current generator, whose armature is driven by the electric motor. The alternating current can be transformed by a stationary transformer to the high pressure necessary.

Another method which has been adopted by Mr. Anderson in his apparatus, and which it is claimed answers the purpose, is to employ the continuous current taken from the lighting or power service of the ship and to subject it to very rapid interruption, very much on the lines of a trembler bell or the induction coil employed with motor cars. A special form of interrupter is used and a charge and discharge of the electrical condenser is obtained, this giving rise to the ozone required, which is directed where it is wanted. In use the ozone generator must be placed in the path of the air current that is to circulate through the lavatory or other space to be dealt with, the ozonized air being allowed to circulate through the space, and the resultant air being carried off by a separate duct in the usual way.

(To be continued.)

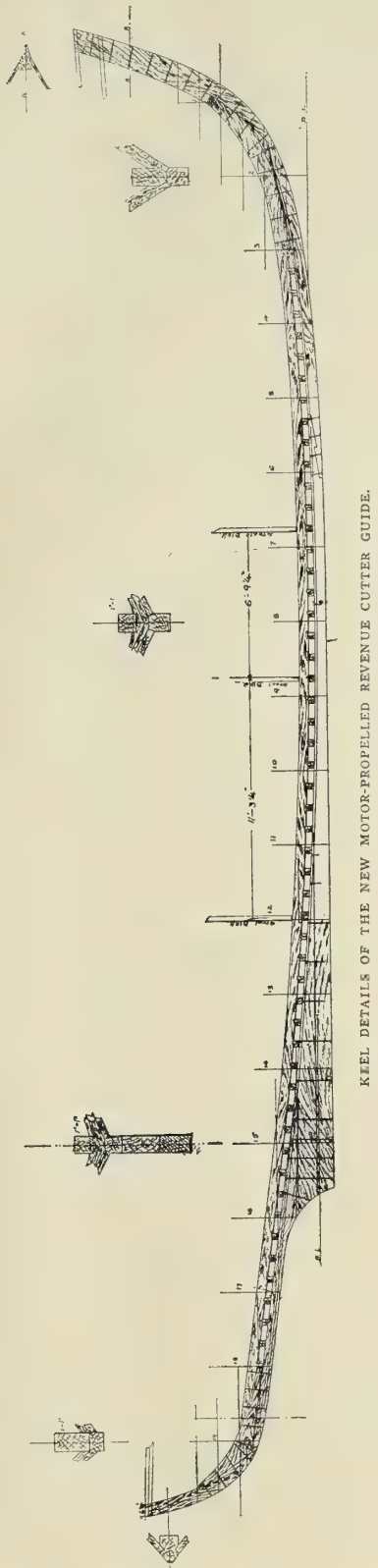


THE MOTOR BOAT GUIDE, OF THE UNITED STATES REVENUE CUTTER SERVICE.

The United States Revenue Cutter Guide.

This 70-foot twin-screw launch, equipped with two 60-horsepower standard engines, has just been completed by the Electric Launch Company, Bayonne, N. J., for the United States Treasury Department, for anchorage service in New York harbor and vicinity. This is the first revenue cutter to be equipped with gasoline (petrol) motors, all boats heretofore being equipped with steam boilers and engines.

The *Guide* is 70 feet in length, 13 feet 6 inches beam, and 4 feet 6 inches draft. Her displacement is 27 tons. The hull is of substantial construction, oak frame, cedar planked, copper

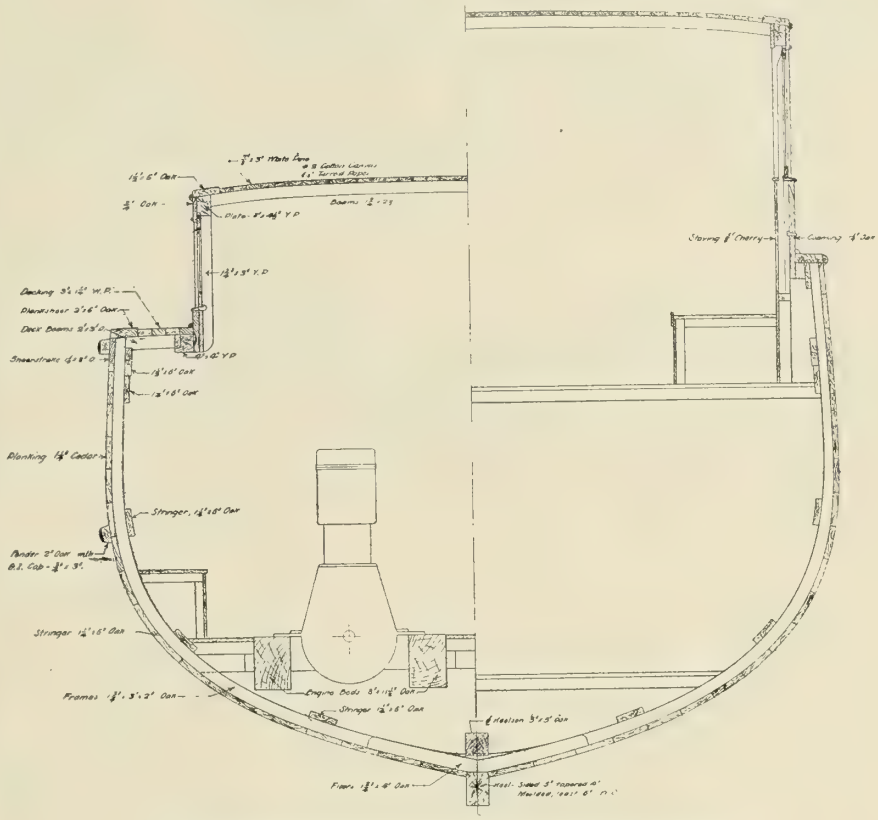


KEEL DETAILS OF THE NEW MOTOR-PROPELLED REVENUE CUTTER GUIDE.

fastened throughout; pilot and cabin house finished outside in quartered oak; interior in oak with mahogany trim and furniture. A spacious forecastle is provided forward for a crew of four men, with large galley in peak. The full width of the boat makes a spacious cabin for dining and officers' quarters. Side transoms are placed, providing for two berths, with large mahogany sideboard and lockers. The boat is steered in pilot house as well as on bridge deck. The gasoline tanks are installed under the flooring of the pilot house, four in number, made of heavy galvanized steel, with a total capacity of 1,000 gallons. The weight of tanks when empty is 3 tons.

Two steel bulkheads separate the engine room from forward and after quarters. Large space is provided for the installation of the two four-cylinder engines, which are capable of driving the boat at a speed of 12 miles an hour. A complete electric light plant is installed, with storage battery auxiliary power; electric lamps being placed throughout the boat, and a powerful searchlight on the pilothouse roof.

The after saloon is 12 feet in length, with side transoms, giving sleeping accommodations for four officers, with mahog-



MIDSHIP AND SCANTLING SECTION OF THE GASOLINE CUTTER GUIDE.

any writing desk, toilet and lavatory compartments. Side decks are provided around the cabin house, with spacious bridge deck, permitting the boat to be handled from outside. The cabins are inclosed by plate-glass windows, dropping down into pockets and giving free ventilation and air throughout.

The requirements under which the vessel was built were somewhat onerous, involving the fitting of a very large amount of material, and the provision of many pieces of equipment and comfort not usually found in vessels of this size. Among other such features might be mentioned a watertight door (really a vertical manhole), with a clear opening of 14 by 20 inches, located on the steel bulkhead just forward of station No. 9. This door measures over all 18 by 24 inches, and is held in place by sixteen ½-inch studs. The door itself is made of 10-pound plate, while the bulkhead is of 7-pound plate. The overlap of the door upon the bulkhead is 2 inches all around, the opening in the bulkhead being stiffened by ⅜-inch bars, covering this space of 2 inches. Between the bulkhead and the door is a rubber gasket, which provides for watertightness when the studs are screwed up hard. The bulkhead itself is stiffened by wooden studding, measuring 1¾ by 3 inches.

A 12-foot boat is carried in chocks on the deckhouse aft of amidships, and may be swung out by means of davits. Forward

of this is the elliptical galvanized steel funnel, measuring 34 by 24 inches, and used for ventilating the engine room. The pilothouse, still further forward, is set down into the hull, and includes a steering station, a cupboard, a buffet and two sofas. It is 15 feet in length. Three flights of stairs, two leading aft to the deck above, and one leading forward to the forecastle, open into this apartment. The entire house, with the exception of the after end, is fitted with windows. Underneath this pilothouse, as shown by the inboard profile, are found quarters for the crew in the forward end and fuel and whistle tanks in the after end.

The entire construction is very heavy, all the metal fittings being of bronze and galvanized steel, to withstand the severe service which a boat like this meets with in boarding vessels entering New York harbor. The boat is built and designed for business all the way through, and is in construction equal to the heaviest steam vessel of her size.

The trial trip of the boat, March 30, was very successful, the engines developing their full power for a period of two hours.

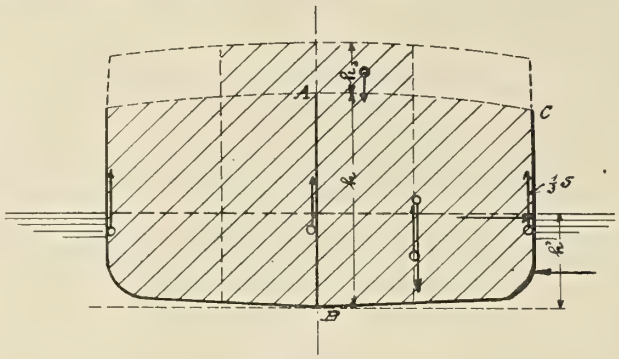
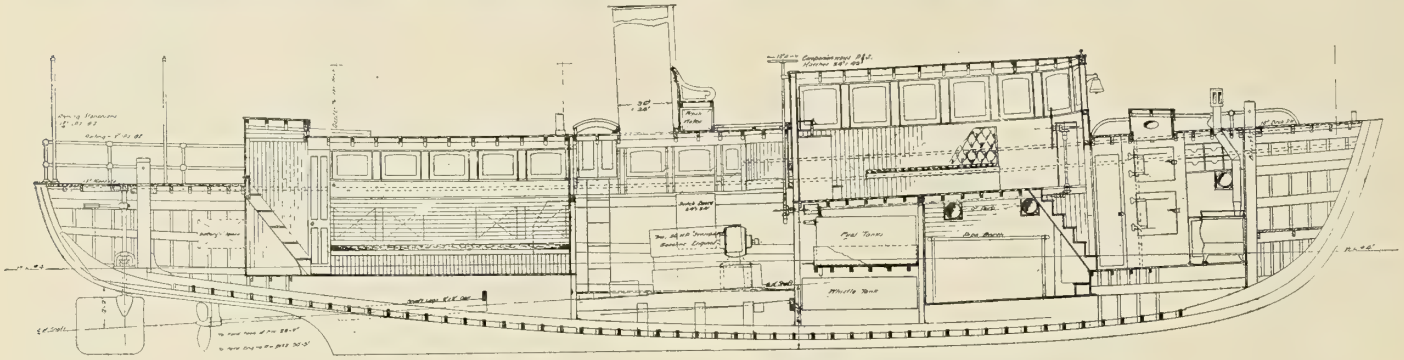
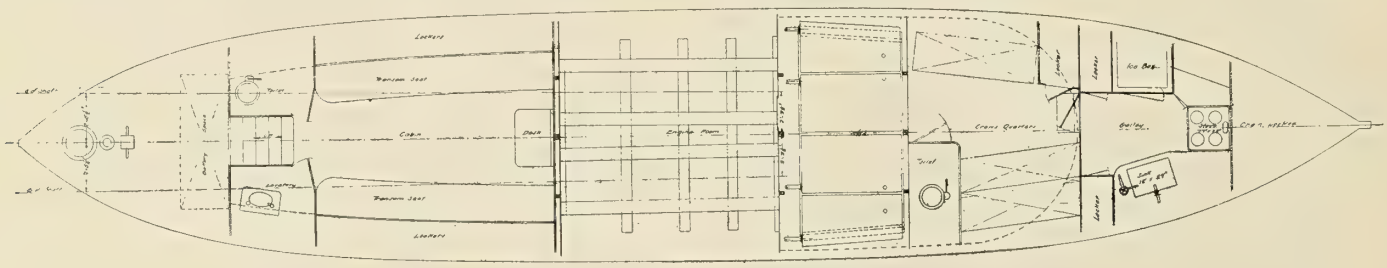


FIG. 6.

The value of the weight may then be indicated, only in case there are certain suppositions on the form of the beam on account of the moment of resistance. Starting from a channel section (see Fig. 7) it may be



INBOARD PROFILE



ARRANGEMENT PLAN

INBOARD PROFILE AND GENERAL ARRANGEMENT PLAN OF THE U. S. REVENUE CUTTER GUIDE.

THE MOST SUCCESSFUL DIMENSIONS OF STEAMSHIPS IN RELATION TO ECONOMY.

BY OTTO ALT, DIPLOM-INGENIEUR.

The moment of the forces produced by the static unequilibrium is to be added to the moment defined in equation (25). For simplicity, only the beam $C\ A$ may be added, and considered a strut to support the frames (Fig. 6). The reaction produced in this way may be calculated only by means of the laws of stresses of materials. Of course, it is dependent, too, on the dimensions, in some way, but such investigations are not yet available.

The whole moment, acting on B, is

$$M_o = M - Z \times h, \qquad (28)$$

where M has the value shown in equation (25).

Speaking of midship sections more complicated, for instance, Fig. 2, generally,

$$M_o = M - M_x, \qquad (29)$$

where M_x means the moment of the unknown statical values.

The stress which will not exceed a certain sum is given by the equation:

$$p = \frac{M_o}{r} \qquad (30)$$

$$r = \frac{s \times h_o}{3}(3b + h_o), \qquad (31)$$

and the weight of the floor will be

$$w_2 = c_o B\ (2b + h_o) \times s \qquad (32)$$

where c_o is a coefficient.

Then there results from (30) and (32)

$$w_2 = c_o \times \frac{B}{h_o} \times \frac{2b + h_o}{3b + h_o} \times M_o. \qquad (33)$$

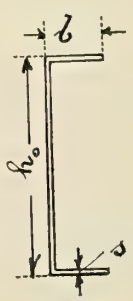


FIG. 7.

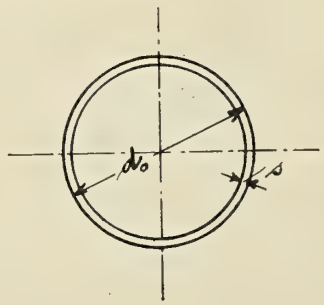


FIG. 9.

From this relation several most interesting and important conclusions result in case the value of M_o is introduced. This will be mentioned elsewhere. All the other transverse structural arrangements, the beams, the stiffening bars of bulkheads, etc., may be managed in the same way, after having found out the bending moment in any direction according to the laws of the theory of elasticity.

The problem of the strength of local structure is yet only beginning to be understood. Therefore, we must try to employ what is known already. According to the experiments of C. Bach,[10] the thickness of plating is to be found from the relation (cf. Fig. 8):

$$s = 0.224\, l \times \sqrt{\frac{\mu \times d'}{\left(1 + \left(\frac{l}{a}\right)^2\right)}}\; p \qquad (34)$$

where μ is a coefficient and d' indicates the mean depth of water, on which the part of bulkhead in question is to be found.

In order to show the dependence on the fundamental dimensions, l is to be set like frame spacing or space of stiffeners; that is to say, either a dependence on the length or on the breadth; and d' is to set like d, and a like the distance of horizontal girders; that is to say, depending on the depth.

Then the weight for a square is

$$w_3 = x \times l \times a \times s \qquad (35)$$

where x is the constant of weight (fundamental constant) or with (34),

$$w_4 = D_o \times l^2 \times a^2 \times \sqrt{\frac{\mu\, d'}{a^2 + l^2}} \qquad (36)$$

a being very great in proportion to l, then

$$w_3 = D_o \times l \times a \sqrt{\mu\, d'}. \qquad (37)$$

In connection with the formula for the weight of stiffening bars, this formula shows which choice of the distance of stiffeners will be the best for the weight.

Usually in shipbuilding only such parts are examined in reference to the racking stress, the racking force of which results from the Eulerian formula for the straight column. For a pillar, for instance, a moment of inertia results from the racking charge

$$Q = c' \times \frac{E \times I}{l_o^2}.$$

E = Young's modulus, l_o = length of column,

$$I = \frac{Q \times l_o^2}{c' \times E}.$$

l_o depends on the dimensions. A hollow cylindrical section being supposed, it will approach (Fig. 9)

$$I = \frac{\pi}{8} \times d_o^3 \times s, \qquad (39)$$

and the weight of the pillar

$$w_4 = x \times \pi \times d_o \times s \times l_o \qquad (40)$$

from the relations (38) to (40), there results:

$$w_4 = F_o \times \frac{Q\, l_o^3}{d_o^2}. \qquad (41)$$

For other forms of cross section, analagous formulas, which may be easily derived, may be found.

The examination will get more difficult as soon as the question comes up of the racking stresses of plates. Therefore, only the case may be considered which exists, in case the deck plating is submitted to a pressure at the longitudinal seams. Then, according to A. E. Love,[11] for special racking forces the relation exists:

$$p = \frac{Q}{F} = \frac{4\pi^2}{l - \mu^2} \times \frac{E \times I'}{l^2}.$$

μ = Poisson's proportion, l = frame spacing, Q = the whole pressure acting on the deck, F = cross section of deck plating, I' = moment of inertia of a cross section with unit length. Then the moment of inertia is given by the relation:

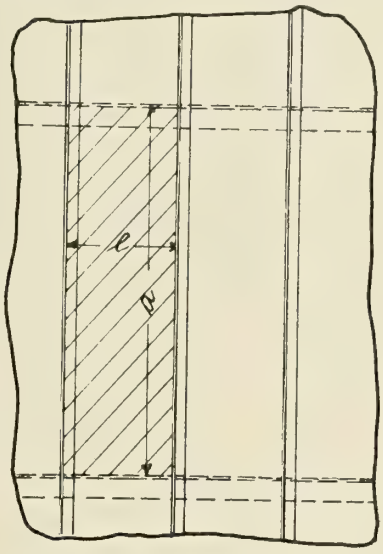


FIG. 8.

$$I' = \frac{p\ (1 - \mu^2) \times l^2}{4\ \pi^2\ E}, \qquad (42)$$

l and I' depend on the dimensions, here, too; thus

$$I' = \frac{s^3}{12} = \frac{Q\ (1 - \mu^2)\ l^2}{B \times s \times 4\pi^2 \times E}, \qquad (43)$$

and the weight of the deck plating over a frame space

$$w_4 = x \times B \times s \times l. \qquad (44)$$

In a similar way as above, there results

$$w_4 = F_o' \times l^4 \sqrt{Q \times B^3 \times l^2}. \qquad (45)$$

In order to find out the whole weight of the hull, W_1, in its dependence on the dimensions, the variations of all the single parts are to be considered. The above gives only an indication.

In order to find out the variation of the weight of machinery with the dimensions, we relate it—as is always done—to the horsepower and to the weight per unit of horsepower:

$$W_2 = \gamma_o \times I\ H\ P.$$

The γ_o of this relation can have most varying values, according to the kind of engine (steam engine, steam turbine, gas engine), to the boiler arrangement (tubular boiler, water-tube boiler) and to their special building. We will refrain from investigating this.

Above all, the question is for a variation of the indicated horsepower with the fundamental variables. According to the usual methods, the power

$$I\ H\ P = y_m \times y_p \times E\ H\ P \qquad (46)$$

when y_m, y_p mean the mechanical efficiency of the engine and of the propeller, and $E\ H\ P$ means the effective power of the propeller.

At first we consider the dependence of $E\ H\ P$ on the dimensions, and, referring to the formula

[10] Elastizität und Festigkeit, Berlin, 1902, page 598.

[11] Treatise on Elasticity, Cambridge, 1892, Vol. II., §381.

$$R = \frac{E\ H\ P}{C \times V}, \quad C \text{ being constant,}$$

we go back to the ship's resistance. Froude has shown in his essay of 1874 that—in order to judge of the question of the "useful displacement"—the dependence of the ship's resistance on the dimensions must be known. It is very interesting to see the progress made in this direction since those days. It is a fact that our knowledge of the "curve of resistance for the ship of each proportion"—as Froude defines it—is a very incomplete one still to-day. We have in this direction principally the researches of G. Rota,[12] who has studied the dependence of the resistance on the dimensions, it is true, but only for one single block coefficient δ, especially for $\delta = 0.5$. In a considerable way these researches were completed by R. E. Froude,[13] who undertook besides this another variation of δ, between limits of 0.4865 and 0.541. But these values are only very rarely used in the building of merchantmen. Besides, some time ago D. W. Taylor[14] published the results of some experiments about the dependence of the resistance on the block coefficient. But these data, given for a battleship, permit only a limited employment for our purpose.

The enormous material that has been collected in the dozen model basins of the different civilized nations is entirely useless, for the greater part, in this question, because usually experiments are undertaken only as far as necessary to gain most favorable lines after having fixed the dimensions.

The better-known fomulas of resistance which have been found have been compiled by W. Johns[15] some time ago; but they do not serve us well, considering our purpose. A great many of the formulas, for instance the French formula

$$I\ H\ P = \left(\frac{V}{m}\right)^3 \times \text{midship section}, \qquad (47)$$

and the English Admiralty formula

$$I\ H\ P = \frac{V^3 \times W^{2/3}}{C}, \qquad (48)$$

show only a very limited variation of the $I\ H\ P$ in changing the dimensions.

Those formulas are more available which separate the resistance into frictional resistance and residuary resistance. But even comparing these formulas with Rota's experiments large mistakes have been prevalent. Perhaps the best formulas for use are those given by D. W. Taylor.[16]

(1) For the frictional resistance:

$$R_1 = f \times S \times V^{1.83}. \qquad (49)$$

S being equal to $C \times \sqrt{W\ L}$, and

(2) for the residuary resistance:

$$R_2 = \frac{12.5 \times W \times \delta \times V^4}{L^2}. \qquad (50)$$

In the first formula C is a coefficient dependent on the proportion B/D. Besides this, the frictional coefficient f is dependent on the length L, as is known. In this formula the fact is very interesting that the frictional resistance increases porportional to $\sqrt{\delta}$ only, while the displacement—and therefore the carrying capacity—grows proportional to δ. As for the rest, there are no certain conclusions for variations, as has been proved in several cases. For instance, in the formula (50) a dependence on the dimensions B and d is not to be found, while Rota has shown one as being a fact.

The performance of the machinery is not thus influenced very much in equation (46), but surely such a dependence exists in the efficiency of the propeller y_P—especially on the draft and on the block coefficient—and this is partly proved by model experiments. Such a dependence is explained easily by differences in the stream lines, *i. e.*, in the speed of the water entering the propeller. There are no experiments in this direction as yet. D. W. Taylor's[17] experiments, the most comprehensive of all, have no direct bearing on this question. Similar it is with the paddle-wheel; here such a dependence exists by virtue of its position and the height of the wave attending the ship.

The weight of fuel W_3 depends generally on the fundamental constant γ_1, of the weight of fuel used per indicated horsepower per hour, on the duration of the voyage, and on the amount of the indicated horsepower. Only these latter are variable with the dimensions, and this in a way which has already been discussed above. As with the fundamental constant γ_1 there are quite similar considerations with regard to γ_0. Here the question of oil fuel, already sufficiently discussed, figures prominently.

The weight of fittings and stores and of equipment varies with the dimensions, too, and this is often caused by the variation of some value already discussed. The different sized surfaces which are to be covered over, the equipment of large and of small rooms, cause variations in the weight, which must be examined in each detailed case. The questions referring to this are mostly of but secondary importance.

There is not much to be said about the other values in equation (15). These values vary from yard to yard with each shipowner and each ship designer, and cannot be considered in a general way.

Perhaps this treatment of the problem of profit is conducive to the usual conclusion of compromises; the empirical seeking for the maximum of profit. Pure examination shows that the attainment of a maximum of profit is given ideally by physical laws and the laws of economy, but that this leads to analyses, most detailed and wasteful of time. Such examinations have a great value only when the opening of a commercial province, distinctly limited, is to be undertaken by a shipowner. In such case the question is to find out, for this determined purpose, a type of ship which tallies with the conditions given above. In this case this type of ship is to be produced in great numbers, so that the profit of such a productive association may be increased in a very considerable way. This method allows interesting prospects for a future enlargement of express steamers—a problem that, at different times, has engaged the attention of shipbuilders.

Finally, I might mention that an examination, brought about by myself according to the above principles, for a tank steamer of 13 900 tons displacement, and of a speed V of 11.5 knots, at a δ of 0.80, showed that the proportions

$L/B = 7.8$ to 8.0; $d/B = 0.45$ to 0.50 and $D/B = 0.56$ to 0.64

characterize the most profitable result.

[12] *Bulletin de l'Association Technique Maritime*, 1900, page 49, and Transactions Institute Naval Architects, 1905, page 334.

[13] Transactions Institution Naval Architects, 1904, page 157.

[14] International Marine Engineering, page 263, July, 1907.

[15] *Engineering*, 1907; also International Marine Engineering, page 261, July, 1907.

[16] Transactions Society Naval Architects and Marine Engineers, 1893, page 226, and 1903, page 243.

[17] Transactions Society Naval Architects and Marine Engineers, 1904, page 107, 1905, page 84, and 1906, page 65.

The number of vessels entered at the port of Yokohama during 1907 was 1,195 of 3,489,822 tons, as compared with 1,062 vessels of 3,276,949 tons in 1906, and 924 vessels of 2,847,031 tons in 1905. The vessels cleared in 1907 numbered 1,110 of 3,303,096 tons; in 1906, 1,052 of 3,240,973 tons, and in 1905, 894 of 2,760,303 tons.

TRIAL PERFORMANCES OF THREE UNITED STATES SCOUT CRUISERS.

Three scout cruisers were authorized by Congress in 1904, and contracts were signed in May of 1905 for their construction. They have just been delivered to the government. While not representing any large military value, these scouts are of great interest from the fact that the three have totally different modes of propulsion, one having the ordinary reciprocating engine; a second, Parsons turbines; while the third has Curtis turbines.

The three ships were given a general description at page 254 in our issue for June, 1905.* Each has a length on the waterline of 420 feet, or 423 feet 1 inch over all; a beam on the waterline of 47 feet 1 inch; and the normal displacement on a draft of 16 feet 9 inches is 3,750 tons. At this displacement, which corresponds with that obtaining on trial trip, the vessels carry 50 tons of feed water and 475 tons of coal, this latter figure being considerably greater than the total bunker capacity of each of the eight British scouts built three years ago. The full bunker capacity of the present vessels is 1,250 tons, and the full load displacement 4,687 tons. Under this condition the draft is 19 feet 1½ inches. With a designed horsepower of 16,000, the contract trial speed of each ship was 24 knots, to be maintained for four hours, in addition to which a number of other tests were prescribed. Each ship has four small funnels, the two center ones being circular in cross-section, while the end funnels are elliptical.† The boiler equipment consists of twelve units in three fire rooms, each containing four boilers. The forward and after funnels serve respectively the forward and after pair of boilers in the forward and after fire rooms; the second funnel serves the after pair of the forward fire room, and the forward pair of the central fire room; the third funnel serves the after pair of the central fire room and the forward pair of the after fire room.

In order to insure the ability of these ships to maintain high speed at sea during all conditions of weather, they have been given a very considerable freeboard, amounting to no less than 34 feet at the bow, 21 feet 6 inches at the stern and 19 feet 8 inches amidship, on normal draft. Each vessel carries two 5-inch rapid fire guns, mounted on the forecastle and poop respectively, and six 3-inch guns amidships. In addition there are two 21-inch submerged torpedo tubes.

The main feature of interest is naturally in the machinery, opportunity having been afforded in this particular case for a thorough testing of three different types of propelling engine under identical conditions. It is the intention of the government to inaugurate a series of races or trials, side by side, thus deriving data in addition to the very considerable amount of information obtained by the regulation trial trips, which occurred during February, March and June of this year.

The *Birmingham,* built by the Fore River Shipbuilding Company, Quincy, Mass., is fitted with twin screws, operated by vertical triple-expansion four-cylinder engines, the cylinders being 28¼, 45, 62 and 62 inches in diameter, with a stroke of 36 inches. The revolutions at full power are about 190 per minute. The twelve boilers are of the Fore River type, with a grate surface at 696 square feet and heating surface 37,992 square feet, the ratio being 54.5 to 1. Each engine is located in a separate watertight compartment and is furnished with steam at a pressure of 250 pounds per square inch.

The *Chester,* built by the Bath Iron Works, Bath, Maine, is fitted with four screws, operated by six Parsons turbines, the revolutions at full speed being about 600 per minute. Each outer shaft has a high-pressure turbine, while the inner shafts are fitted with two turbines each, one being the low-pressure and the other a cruising turbine. The astern turbines are located, as usual, in the after end of the low-pressure casing. The starboard inner shaft carries the high-pressure cruising turbine, and the port inner shaft the intermediate-pressure cruising turbine. At low speed these two turbines are used in conjunction with the two low-pressure turbines, on the same shafts. Steam is furnished by Normand water-tube boilers; the feed heaters are also of the Normand type, there being one end-pressure heater in each of the two engine rooms. The boiler heating and grate surfaces are 32,040

THE AMERICAN SCOUT CRUISER CHESTER, STEAMING AT OVER 26 KNOTS ON FOUR-HOUR OFFICIAL TRIAL TRIP.
(Copyright, 1908, N. L. Stebbins.)

* And the *Salem* at page 410, October, 1907.

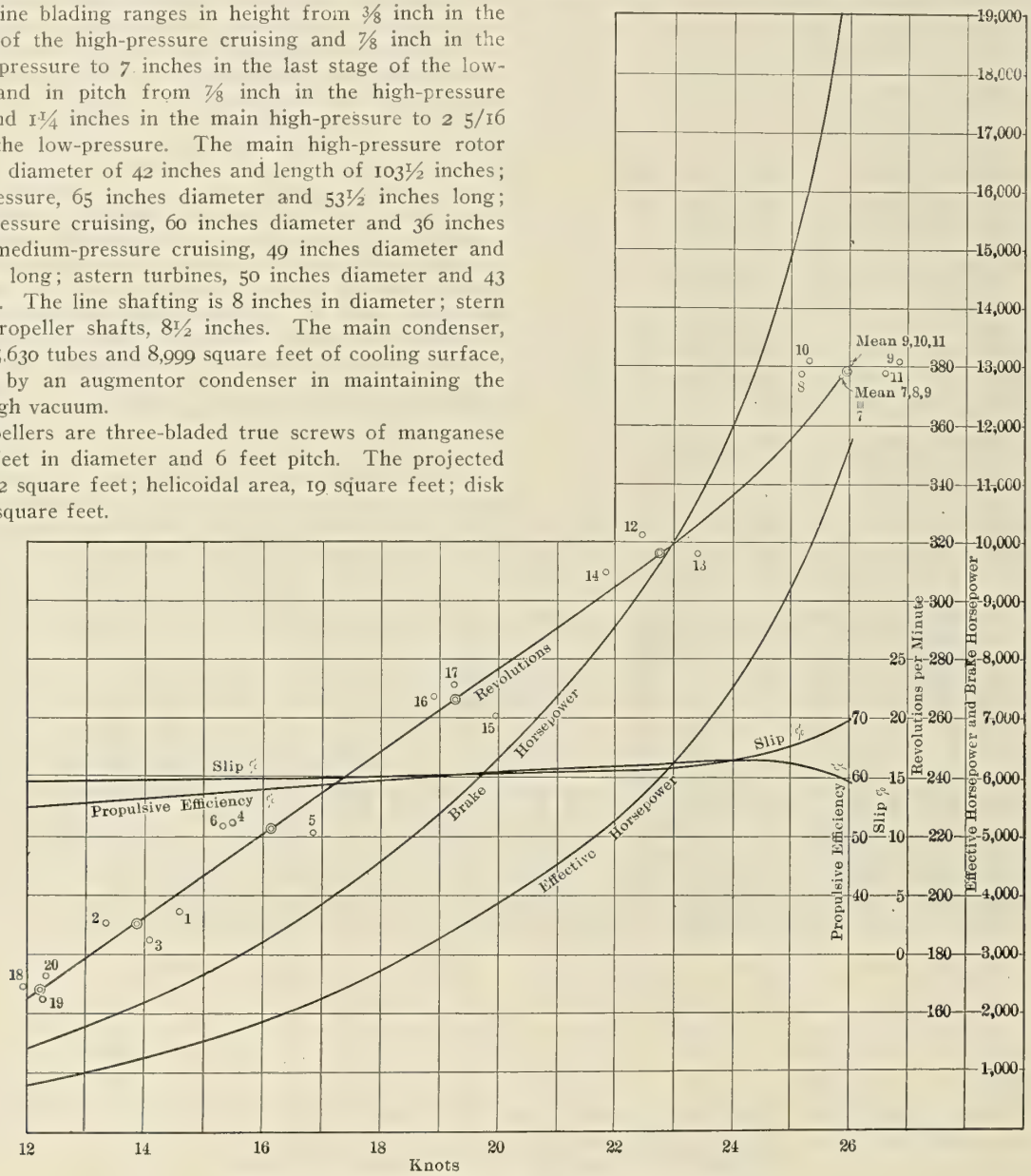
† Except in the *Chester,* where circular funnels with small inner tubes are fitted.

and 696 feet, a ratio of 46 to 1. The steam pressure is 250 pounds per square inch. Each boiler, with water for steaming, weighs 19.7 tons. The entire machinery weights come slightly under the stipulated limit of 793 tons. The funnels, 6 feet in diameter, stand 63 feet 3 inches above the grates.

The turbine blading ranges in height from 3/8 inch in the first stage of the high-pressure cruising and 7/8 inch in the main high-pressure to 7 inches in the last stage of the low-pressure; and in pitch from 7/8 inch in the high-pressure cruising, and 1¼ inches in the main high-pressure to 2 5/16 inches in the low-pressure. The main high-pressure rotor drum has a diameter of 42 inches and length of 103½ inches; the low-pressure, 65 inches diameter and 53½ inches long; the high-pressure cruising, 60 inches diameter and 36 inches long; the medium-pressure cruising, 49 inches diameter and 60½ inches long; astern turbines, 50 inches diameter and 43 inches long. The line shafting is 8 inches in diameter; stern tube and propeller shafts, 8½ inches. The main condenser, which has 5,630 tubes and 8,999 square feet of cooling surface, is assisted by an augmentor condenser in maintaining the requisite high vacuum.

The propellers are three-bladed true screws of manganese bronze, 6 feet in diameter and 6 feet pitch. The projected area is 17.02 square feet; helicoidal area, 19 square feet; disk area, 28.27 square feet.

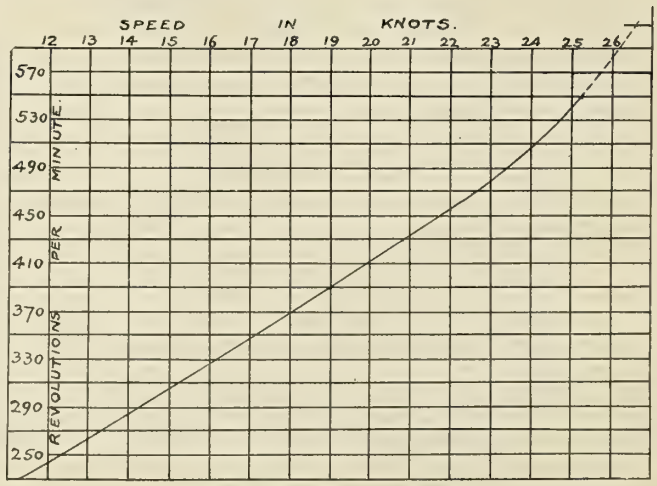
end of the run the displacement would be less than 3,750 tons by a similar amount, and the average displacement in each case figured out very closely to the specified trial figure. In the case of the *Salem* the average was 3,745 tons. In the case of the *Chester*, it was 3,717 tons.



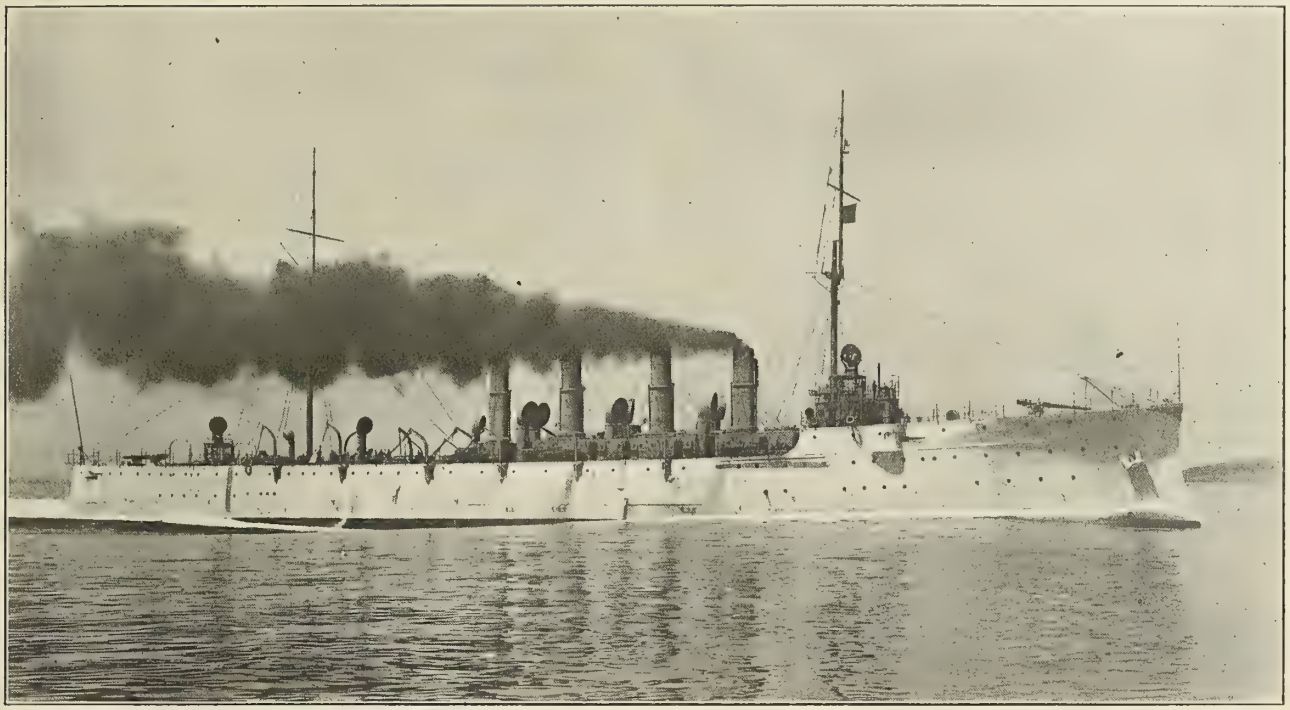
CURVES FROM STANDARDIZATION RUNS OF THE SCOUT CRUISER SALEM.

The *Salem*, built by the Fore River Shipbuilding Company, is propelled by twin screws, actuated by Curtis turbines of the 7-stage type, 120 inches in diameter, the revolutions at full speed being about 375 per minute. These are located in two separate compartments; the port turbine is aft and the starboard turbine forward. Each turbine has an outside diameter of 11½ feet, and a length of 15 feet.

The trials started with standardization runs to determine the number of revolutions of the propellers necessary to give the designed full speed, as well as the other prescribed trial speeds. These were followed by a four-hour full power trial, under which an air pressure of 5 inches was permissible. Two 24-hour endurance runs at 22½ and 12 knots respectively, completed the steam trials. In each case the probable consumption of coal during the runs was computed beforehand, and the displacement of the ship was so adjusted that it would be greater than the designed displacement of 3,750 tons by one-half this amount of coal. Naturally, at the



STANDARDIZATION CURVE OF CHESTER.



THE CURTIS-TURBINE-PROPELLED SCOUT CRUISER SALEM ON OFFICIAL FOUR-HOUR TRIAL TRIP.
(Copyright, 1908, N. L. Stebbins.)

The table gives very clearly the general results of the four sets of trials, and shows the superior economy of both the turbine-propelled ships, as compared with the *Birmingham.* The superiority of the *Birmingham* at full speed is explained by the fact that her full speed was approximately two knots less than that of the other two ships. If we reduce the speeds of the *Salem* and *Chester* to 24.325 knots, on the assumption that the power (and consequently coal consumption per hour) varies as the cube of the speed, we find that the radius of the *Salem* becomes 1,634 nautical miles, and of the *Chester* 1,746 nautical miles, as compared with 1,730 for the *Birmingham.* It will be noted that these figures have been based upon the consumption of 950 tons of coal, instead of either the normal coal supply or the full bunker capacity. This is due to a desire to use the results as shown on trials, and it is possible to do this only by so adjusting matters as to make the average displacement close to 3,750 tons. We have, therefore, assumed that each ship starts such a run with double the normal coal supply, and ends it without any coal.

In addition to the data given in the table and on the diagram, showing standardization results for the *Salem,* we may say that the air pressure during the 4-hour run was only 4 inches of water, in place of the 5 inches allowed. The flue gas temperature averaged 750 degrees F. The brake horsepower, as given by a Foettinger torsion meter, was 19,200, which compares very closely with the 19,015 horsepower given by a Denny-Johnson torsion meter. At 22½ knots speed, the *Salem* used 2 inches air pressure and showed a flue gas temperature of 585 degrees; at 12 knots the air pressure was 1 inch and the flue gas temperature 525 degrees. On this trial only four boilers were used. The high run on the standardization trials was made with 3.8 inches of air pressure, and showed 20,200 brake horsepower, with 382.4 revolutions per minute; the speed was 26.886 knots. The propellers of the *Salem* are three-bladed, with a diameter of 9 feet 6 inches and a pitch of 8 feet 8 inches. The pitch ratio is 0.912; the developed area, 43.7 square feet; the developed area ratio, 0.616; and the projected area, 38.2 square feet.

In the starting and stopping tests, at a speed of about 24¼ knots, the *Salem* was stopped dead in the water and started astern in 2 minutes 48 seconds. From the giving of the signal until the turbines had stopped a period of 42 seconds

Scout Cruiser Trials.	Birmingham.	Salem.	Chester.
Standardization Date	March 11	June 23	Feb. 28
Best uncorrected run, knots	25.192	26.886	26.22
Mean of best pair of runs, knots	24.477	26.11	25.138
Mean of five high runs, knots	24.236	25.957	25.074
R. P. M. required for 24 knots	187.23	335.2	507.25
R. P. M. required for 22.5 knots	170.38	312.	466.4
R. P. M. required for 12 knots	89.7	165.	245.5
Full speed, four hours Date	March 12	June 25	March 1
Mean displacement	3,720.	.....	3,673.
Mean speed	24.325	25.947	26.52
Mean R. P. M.	191.66	378.39	614.31
Apparent mean slip, percent	15.8	19.8	25.6
Coal per hour, pounds	29,904.	38,502.	38,332.
Indicated horsepower	15,540.	21,333.*	.....
Admiralty coefficient	222.5	197.5	.....
Brake horsepower	.....	19,200.	Unknown†
Coal per I. H. P. per hour	1.92	1.81*	.....
Coal per B. H. P per hour	.....	2.01	?
Miles per ton of coal	1.822	1.51	1.548
Radius (nautical miles) *a*	1,730.	1,434.	1,471.
Twenty-four hours at 22.5 knots Date	March 14	June 30	March 3-4
Mean displacement	3,741.	.....	3,716.
Mean speed	22.665	22.536	22.779
Mean R P M	172.1	312.535	473.34
Apparent mean slip, percent	12.6	15.7	18.7
Coal per hour, pounds	20,510.	18,485.	18,063.
Indicated horsepower	10,760.	10,378.*	.....
Admiralty coefficient	260.9	266.5	.....
Brake horsepower	.....	9,340.	Unknown†
Coal per I. H. P. per hour	1.91	1.78*	.....
Coal per B. H. P. per hour	.....	1 97	?
Miles per ton of coal	2.475	2.73	2.83
Radius (nautical miles) *a*	2,348.	2,593.	2,686.
Twenty-four hours at 12 knots Date	March 13	June 26-27	Feb. 28-29
Mean displacement	3,743.	.....	3,710.
Mean speed	12.228	11.937	12.2
Mean R. P. M.	91.4	164.11	249.7
Apparent mean slip, percent	11.2	15.15	17.5
Coal per hour, pounds	4.629.	4,051.	4,091.
Indicated horsepower	1,600.	1,511.*	.....
Admiralty coefficient	275.2	271.7	.....
Brake horsepower	.....	1,360.	Unknown†
Coal per I. H. P. per hour	2.89	2 68*	.....
Coal per B. H. P. per hour	.....	2.98	?
Miles per ton of coal	5.965	6.6	6.66
Radius (nautical miles) *a*	5,643.	6,269.	6,338.

* Equivalent I. H. P. based on assumption of 10% engine friction.
† Torsion meter gave totally unreliable readings, going as high as 28,000 horse power at full speed.
a Starting with 950 tons of coal

had elapsed, while a further period of 48 seconds was required to bring the turbines up to full speed astern. From full speed of ship astern until the turbines were at rest required 15 seconds; from full speed astern until the turbines were running full speed ahead, the time was 1 minute 4 seconds.

The curve of propulsive efficiency for the *Salem* is particularly interesting, showing a maximum of nearly 63 percent at from 24 to 24½ knots, and a figure of more than 59 percent at 26 knots. Reducing these figures to corresponding amounts for equivalent indicated horsepower we find that the maximum would be about 56½ percent, and the figure at 26 knots about 53½ percent, both being splendid results.

Special features of the trials of the *Chester* follow in tabular form. It may be said that during the 22½ knot trial there was in operation a considerable amount of auxiliary machinery, including the evaporating and distilling plant, ice-making plant, ash hoists (as required), complete ventilating and steam heating systems, and all auxiliaries required in operating machinery. The astern trials on March 4 were made under a steam pressure of 105 pounds per square inch, the revolutions per minute being 390, and the speed astern 12 knots.

Twenty-four-Hour Endurance Trial at 12 Knots, February 28 and 29, 1908.

Average Pressure, Pounds per Square Inch Gage.	Forward Engine Room.	After Engine Room.
Main steam	155. lbs.	147.4 lbs.
High-pressure turbine	10.3 lbs.	8.2 lbs.
Low-pressure turbine, vacuum	23.41 ins.	23.4 ins.
H. P. cruising turbine	83.2 lbs.	.....
I. P. cruising turbine	20.9 lbs.	.....
Mercury gage (condenser vacuum)	29.0 ins.	28.8 ins.

Barometer at start of trial	29.75 ins.
Four boilers only used—grate surface	232 sq. ft.
With natural draft, coal consumption per sq. ft. of grate surface	17.7 lbs.

Twenty-four-Hour Endurance Trial at 22½ Knots, March 3 and 4, 1908.

Average Pressure, Pounds per Square Inch Gage.	Forward Engine Room.	After Engine Room.
Main steam	230 lbs.	230 lbs.
High-pressure turbine	98 lbs.	93 lbs.
Low-pressure turbine	0 lbs.	2.25 ins.
H. P. cruising turbine, vacuum	19 ins.	.....
I. P. cruising turbine	180 lbs.	.....
Mercury gage (condenser vacuum)	29.9 ins.	29.3 ins.
Second expansion, H. P. turbine	53 lbs.	50 lbs.
Auxiliary exhaust	.....	2 lbs.

Temperature of feed heater outlet	185° F.	204° F.
Main injection	35° F.	
Outboard delivery	64° F.	
Coal per sq. ft. of grate surface per hour.	26 lbs.	
Air pressure	0.7 inch.	

Four-Hour Full Speed Trial, March 1, 1908.

Auxiliary exhaust	16 lbs.
Temperature of feed heater outlet, mean	217.5° F.
Outboard delivery	75° F.
Main injection	34° F.
Coal per sq. ft. of grate surface per hour	55 lbs.
Air pressure—Maximum	3 ins.
Average	2.75 ins.
Highest speed for 15 minutes	26.6 knots.

Average Pressure, Pounds per Square Inch Gage.	Forward Engine Room.	After Engine Room.
Main steam	243.5 lbs.	246.7 lbs.
High-pressure turbine	238.7 lbs.	239.5 lbs.
Low-pressure turbine	15.5 lbs.	15 lbs.
Mercury gage (condenser vacuum)	28.8 ins.	28.3 ins.
Second expansion, H. P. turbine	159.5 lbs.	149.8 lbs.
H. P. cruising turbine, vacuum	20 ins.	.....
I. P. cruising turbine, vacuum	20 ins.	.....
Astern turbine	28 ins.	28 ins.

In the full-power trial of the *Birmingham* the air pressure was kept at 2¾ inches, the steam pressure at the engines was 225 pounds per square inch, and the vacuum averaged 26.4 inches. During the 24-hour trial at 22½ knots, these figures were, respectively, 1.08 inches, 174½ pounds, and 27.1 inches. The 12-knot trial gave corresponding results of ¼ inch, 151½ pounds, and 26.8 inches.

The success attending the trials was anticipated by the naval constructors in the demonstration of the design three years ago in the model basin at the Washington navy yard. It was there found that a vessel of 4,000 tons displacement and 350 feet long required, in order to make 26 knots, more than double the horsepower of a vessel of the same displacement, but made narrower and shallower, and stretched to 450 feet in length.

A feature which impressed the observers on board the *Birmingham* and *Chester* was the advantage obtained by the *Chester* in lack of vibration, a characteristic which contributes to the steadiness of the vessel as a gun platform. In the case of the *Birmingham*, the vibration from the reciprocating engines was at times positively unpleasant, especially when the ship was running at high speed, and was particularly noticeable in the cabins even when the vessel was at 22.5 knots, while on the *Chester* there was hardly any perceptible vibration. The advocates of the turbine have extracted much comfort from this practical demonstration, and are more than ever confident that the day of the reciprocating engine for large ships of war has virtually passed.

MARINE ENGINE DESIGN.

BY EDWARD M. BRAGG, S. B.

RECIPROCATING MEMBERS.

The reciprocating parts of a marine engine are usually designed for the maximum load to which the parts will be subjected. This load cannot be determined before the engine is built, as it depends largely upon the valve setting, and the indicator card is needed in order that the steam load may be determined. The maximum load can be determined approximately, however, by means of factors obtained from the analysis of the results of engine trials. If *I. H. P.* is the indicated horsepower developed in a cylinder with a piston speed per minute = *P. S.*, then the mean total load acting upon the piston

$$= \frac{I.H.P. \times 33{,}000}{P.S.}.$$

It has been found in the results analyzed that the maximum load was about 1.93 of this mean theoretical load. The formula to be used here for finding the maximum load for which the reciprocating parts are to be designed is, therefore,

$$W = \frac{2 \times I.H.P. \times 33{,}000}{P.S.}, \qquad (20)$$

where *I. H. P.* is the indicated horsepower to be developed in the cylinder in question. It will be found that this gives

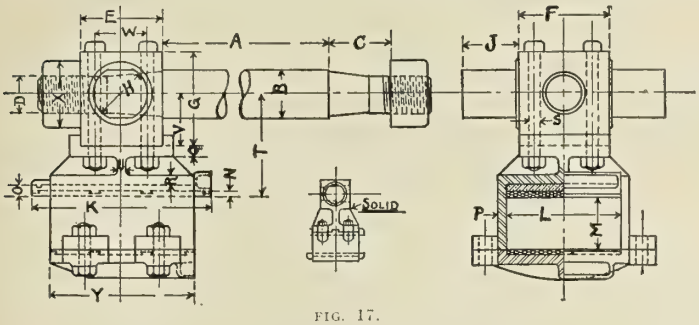


FIG. 17.

PISTON ROD, CROSSHEAD AND BOX GUIDE.

A	B	C	D	E	F	G	H	J	K	L	M
3′ 2″	3½″	.....	3″	7″	7½″	7″	4½″	5½″	14″	9″	.....
3′ 7″	3⅜″	5½″	3″	7″	8″	8″	4½″	4¾″	15½″	10″	4½″
4′ 0⅝″	3⅞″	5⅜″	3¼″	7″	7″	8″	4½″	4⅝″	17″	8″	4½″
3′ 11¼″	4¼″	7½″	3½″	8″	8″	8½″	4¾″	5⅜″	16″	11″	5″
.....	5″	.....	3⅜″	9½″	9½″	9½″	6″	6⅝″	21″	12⅛″	6½″
4′ 10″	6½″	7½″	5½″	10″	10″	10″	7¾″	7½″	22″	16″	6½″
4′ 6″	4⅞″	7½″	3⅜″	8½″	8″	8″	5¼″	6¾″	17½″	13″	4¾″
2′ 10″	2⅝″	4″	2″	5″	5″	5″	3½″	4″	10″	7″	3″

N	O	P	Q	R	S	T	U	V	W	X	Y
7/16″	1¼″	.....	.....	7/8″	1⅛″	.....	.....	.....	.....	.....	.....
⅜″	⅞″	⅝″	⅞″	¾″	1″	8½″	¾″	4⅜″	4½″	5¾″	12½″
⅜″	1″	⅞″	1″	⅞″	1″	4¼″	⅞″	4½″	4¼″	5⅝″	14″
⅜″	1⅛″	⅞″	1″	15/16″	1⅛″	10″	⅞″	4½″	5″	6⅛″	13″
½″	1½″	1¼″	1½″	.....	1¼″	14½″	⅞″	4¾″	5½″	.....	21″
⅞″	1½″	1″	Solid	1″	.....	14¼″	1¼″	.....	.....	.....	22″
½″	.....	.....	Solid	.....	1⅛″	12½″	.....	.....	.....	6¾″	13″
.....	¾″	¾″	Solid	1″	¾″	7″	1¼″	.....	.....	.....	8″

very nearly the same results as the formula often used, $W =$ area $\times$ boiler pressure.

Piston Rods.—Piston rods are usually of the shape shown in Figs. 17, 18, 19 and 20, with a parallel middle body subjected to alternating loads, shouldered at each end of the parallel body to take the thrust, and threaded portions beyond to take the tension, the latter portions being subjected to intermittent loads. A column formula must be used for the design of the middle portion, and in these calculations a formula based upon Rankine's long column formula will be used.

The formulæ for solid and hollow rods are as follows:

Solid rods, $$D^2 = \sqrt{\frac{0.48FCl^2}{10{,}000{,}000} + F^2} + F; \qquad (21)$$

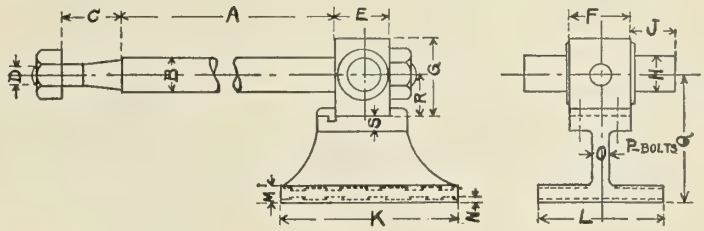


FIG. 18.

PISTON ROD, CROSSHEAD AND SINGLE SLIPPER GUIDE.

A	B	C	D	E	F	G	H	J
4′ 7¼″	5″	.....	4½″	9″	9½″	9″	6″	7″
5′ 6½″	5¾″	.....	4⅜″	10¼″	11″	11″	7¼″	5½″
5′ 0½″	5¾″	.....	5″	11″	10⅛″	10½″	7¼″	8½″
5′ 5⅝″	7″	9″	5½″	12″	13″	12″	7½″	9″
7′ 7″	7½″	.....	5¼″	13½″	12⅜″	13½″	9½″	10″
5′ 8¹³/₁₆″	7½″	.....	6½″	14″	14″	14″	10½″	11¼″
9′ 2¾″	8½″	.....	5″	16″	17″	18½″	11″	13½″
5′ 3⅞″	8⅛″	10″	6½″	14½″	15″	14″	9″	11″
4′ 0⅞″	4½″	4½″	3¼″	7″	7½″	8¾″	5″	5⅜″

K	L	M	N	O	P	Q	R	S
21″	12½″	2½″	7/16″	3¼″	4′ 1⅜″	.....	.....	.....
27″	13½″	2¾″	½″	3″	4′ 1⅜″	.....	.....	.....
24″	16″	3″	½″	3″	4′ 1⅜″	.....	.....	.....
23½″	19″	2½″	½″	2¾″	6′ 1½″	17½″	6½″	1½″
30″	22½″	3¼″	½″	3″	4′ 1⅜″	.....	.....	.....
30″	26″	3½″	½″	3½″	4′ 2″	.....	.....	.....
44″	25½″	3¾″	½″	4″	4′ 2¼″	26″	10″	2½″
26″	24″	3″	½″	3¼″	4′ 2″	19½″	7″	1⅝″
16″	14″	1¾″	7/16″	1¼″	2′ 1½″	12⅜″	5″	1⅛″

Hollow rods, $$D^2 = \sqrt{\frac{0.48FCl^2}{10{,}000{,}000} + F^2 + (2F + d^2)d^2} + F; \qquad (22)$$

where $D =$ the diameter of the rod in inches at the middle of its length;

$$F = \frac{2W}{\pi f};$$

$W =$ load on rod (Formula 20);

$f =$ allowable stress per square inch $= \frac{C}{N}$;

$C =$ the ultimate strength of the material,
$=$ 60,000 to 70,000 pounds for merchant work,
$=$ 80,000 to 100,000 pounds for naval work;

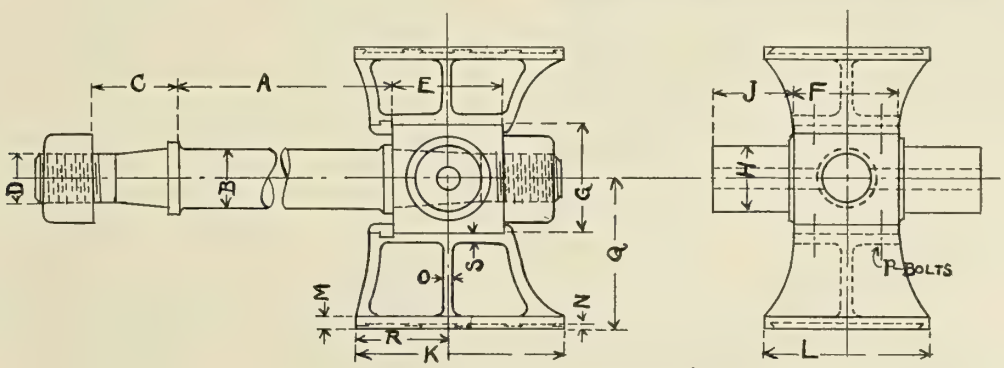


FIG. 19.

PISTON ROD, CROSSHEAD AND DOUBLE SLIPPER GUIDE.

A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S
5′ 2″	6¼″	9″	5¼″	11½″	10¾″	11½″	7″	8½″	22″	17″	1½″	½″	1″	4′ 1¼″	14″	10″	1¼″
.....	4″	.....	.....	9¾″	10″	9½″	5″	6½″	19″	12″	1¼″	½″	⅞″	.....	12″	9½″	1¼″
5′ 5¾″	6½″	.....	5¼″	10″	11″	10″	6½″	7¾″	24″	12″	1⅝″	½″	1″	4′ 1⅜″	.....	.....	.....

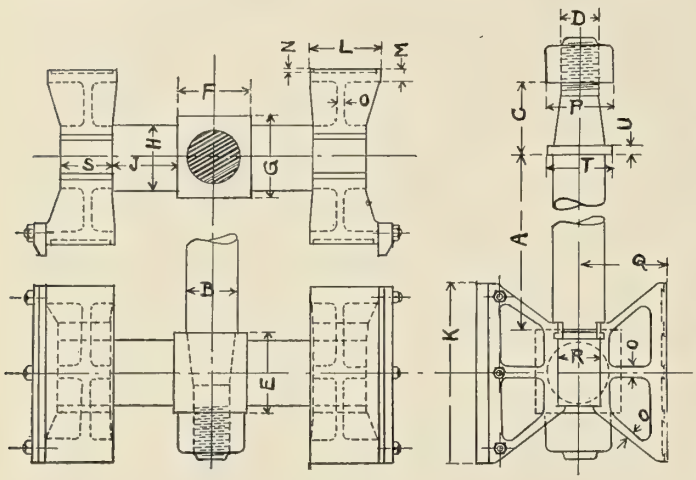


FIG. 20.

PISTON ROD, CROSSHEAD AND FOUR SLIPPER GUIDE.

A		B	C	D	E	F	G	H	J	K
8′	8¼″	8″	11½″	6″	13″	11½″	13″	10½″	10″	28″
9′	6″	11″	13″	8¾″	16½″	15¾″	16¾″	13¾″	16½″	47″

L	M	N	O	P	Q	R	S	T	U
11″	2″	.....	1″	10½″	14″	7″	8″	10″	1½″
20″	2¼″	¾″	1″	13¼″	17¾″	8½″	14″	12″	1¼″

N = factor of safety = 8 to 10 for torpedo boat engines,
= 12 to 14 for other naval engines,
= 15 for merchant ship engines;

l = length of rod in inches from under side of piston to upper side of crosshead block = (approximately) stroke + diameter of high-pressure cylinder + X, where X = 2 to 8 inches for merchant ship engines, = − 2 to − 8 inches for naval engines;

d = inside diameter of hollow rod, and may be taken from $\frac{1}{2}\sqrt{2F}$ to $\frac{2}{3}\sqrt{2F}$.

In discussing the factors of safety to be used for different kinds of loads, it was stated that 12 would be used for alternating loads. It was also stated that these factors would be modified sometimes by reason of the conditions under which the part worked. The piston rod is guided more or less rigidly at three points: at the piston by the piston rings, at the stuffing-box, and at the cross-head. These three points may be out of line in the first place, or may get out of line as the engine works, and thus cause the rod to have an initial flexure at times. The factor 0.48 in the formula assumes that the rod is held rigidly at the cross-head end, and that only two-thirds of its length is subjected to bending, whereas it is probable that it is not held rigidly at the cross-head. A third reason for modifying the factor is that the rod is working a part of the time in steam and part in the open air, and runs through a stuffing-box, which may get hot and grip it. When all of these conditions are considered it seems wise to increase the factor of safety from 12 to 15 for this member.

The thrust of the rod is transmitted to the piston and crosshead block by means of a shoulder, either positive, as in Figs. 19 and 20, or negative, as in Figs. 17 and 18. This shoulder, when negative, has a breadth of 1/16 inch in the smallest rods and 3/16 in the largest rods. When the shoulder is positive it is generally broader, varying from ¼ inch to ½ inch. The threaded portion of the rod, having to transmit tension only, is designed to have sufficient area at the root of the threads to transmit the load with a factor of safety of 10. As four threads per inch are generally used, the diameter of this portion must be increased by

$$\frac{1.299}{4} = 0.325 \text{ inch (about)},$$

to allow for cutting the threads. The diameter of the threaded portion, taken to the nearest ¼ inch, should be:

$$D' = \sqrt{\frac{40W}{\pi C}} + 0.325. \qquad (23)$$

(W and C are as above.)

The connection between the shoulder and the threaded portion is usually made by means of a tapered part, the taper being 2 or 3 inches per foot. Cylindrical nuts are generally used in attaching the piston and the cross-head.

The length of the rod between shoulders will be given only approximately by the formula L = stroke + high-pressure diameter + X. This is near enough for calculation, but the final length should be determined from the assembly drawing.

Bearing Pressures.—Before proceeding further with the design of the reciprocating parts, it will be well to take up the question of pressures allowed upon bearing surfaces. It is usual to figure the bearing surface of pins and shafts as equal to the length of the surface multiplied by the diameter of the pin or shaft, *i. e.*, as equal to the *projected* area of the bearing. The pressure allowed must be low enough to keep the bearing cool, and varies with the conditions and the possibility of artificial cooling. When there is no motion between two parts the pressure between them can be very large, but as the extent of the motion between them increases the pressure allowed decreases. Since it is a question of keeping the bearing cool, we can deal with the mean unit bearing pressure, since the maximum will occur generally but for an instant. In some cases, however, it is more convenient to deal with the maximum pressure to avoid confusion. The pressures allowed upon the different surfaces are shown in Table VII. The

TABLE VII.

Allowable pressure on bearing surfaces in pounds per square inch of projected surface:

	Merchant.	Naval.
USING MEAN LOADS—		
Crank Pin	200 to 250	250 to 300
Main Bearings	200 to 350	250 to 500
USING MAXIMUM LOADS—		
Slipper Guide	60 to 80	70 to 100
Crosshead Pins	850 to 1,200	1,200 to 1,800
Link Block Pin	750 to 1,000	850 to 1,200
Link Block Gibs	250 to 400	350 to 500
Eccentric Rod Pins	700 to 950	900 to 1,100
Drag Rod Pins	500 to 700	700 to 800
Eccentrics	150 to 200	175 to 225
Thrust Collars	50 to 80	80 to 100

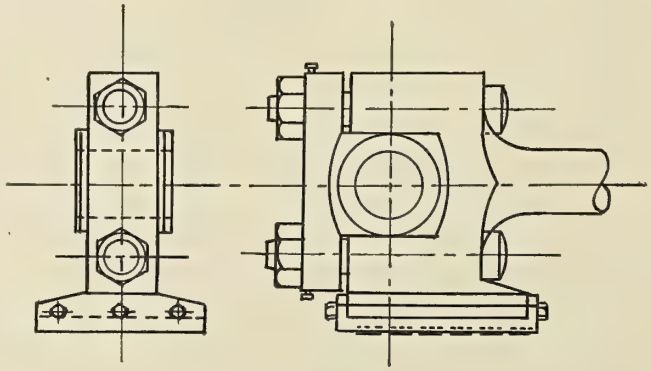


FIG. 21.

most of the pressures are based upon the maximum loads, as these loads are used in the design of the other parts, and it is less confusing to deal with but one load. It will be noticed that those surfaces which have but little relative motion have the greatest unit pressure allowed upon them, while those with more motion, such as the slipper, main bearings and crank pins, have a lower unit pressure allowed. The question of the determination of the loads coming upon the different surfaces will be taken up later.

Cross-Head Block.—There are two types of cross-heads, those with external bearing surface, as shown in Figs. 17, 18, 19 and 20, and those with internal bearing surface, as shown in Fig. 21. When the bearing surface is external, the block is approximately a cube, with the two cross-head pins projecting from two opposite faces. When the bearing surface is internal, the cross-head consists of a box, with bottom brass and cap, in which works a pin held fast in the jaws of the connecting rod fork. (See Fig. 22.) This latter type is used principally upon small, fast running engines, and upon torpedo boat engines.

The cross-head block with external bearing surface is generally from 1.8 D to 1.9 D upon a side (D being the

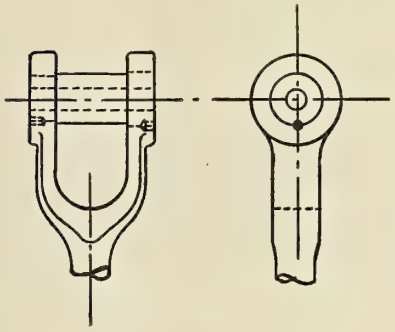


FIG. 22.

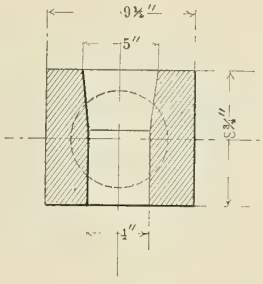


FIG. 23.

diameter of the piston rod), and tends to split upon a plane passing through the axis of the piston rod, where the cross-section of metal resisting the bending moment is shaped as shown in Fig. 23. The bending moment upon this section will be

$$M = \frac{WL}{4},$$

where W is the load previously found, and L is the distance from center to center of cross-head pins.

Cross-Head Pins.—The maximum load W, divided by P, the allowable pressure upon the cross-head pins, taken from Table VII., will give the surface that must be provided in these pins, or

$$l \times d = \frac{W}{2P},$$

where l = the length of one pin and d = its diameter. The diameter d should be from 1.2 D to 1.4 D, where D is the diameter of the piston rod. This will give a pin with a sufficiently strong attachment to the block, so that no other calculation need be made upon it. This diameter of pin may have to be changed later on, when the dimensions of the upper end of the connecting rod are known, but it is sufficiently close for calculation. The length of the pin will usually come about equal to its diameter.

The breadth of the block having been assumed, and the length of the pins found, the bending moment $\frac{WL}{4}$ can be found.

The moment of inertia of the section resisting the bending is

$$I = \frac{bh^3}{12},$$

where b is the net breadth after taking out the piston rod hole, and h is to be found so that the stress shall be reasonable.

$$h = \sqrt{\frac{3WL}{2bf}}. \qquad (24)$$

Here f should be chosen so that the factor of safety will be 12. The cross-head blocks are usually made of wrought steel, or cast steel, with the pins hardened. A facing strip should be allowed around each pin, from 1 inch to 2 inches wide, and projecting from the block 1/16 to ⅛ inch.

If the cross-head has internal bearing surface, the length and diameter of the bearing are calculated in the same way as are the pins,

$$l \times d = \frac{W}{L}.$$

The length of the pin determines the thickness of the block, and the other details are figured in the same way as are the boxes of the connecting rod, whose design will be taken up later.

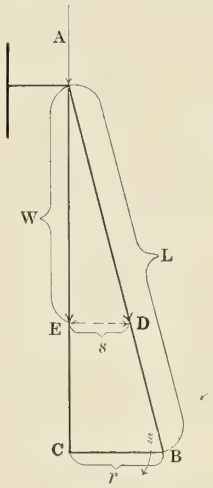


FIG. 24.

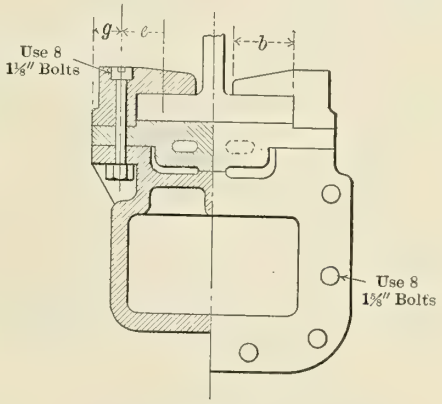


FIG. 25.

Slipper.—The slippers attached to the cross-heads are usually one of the four types shown in Figs. 17, 18, 19 and 20. Fig. 17 shows the type used upon many small engines of 1,000 indicated horsepower and less. It is a cast-steel box, inclosing for a guide a square cast-iron beam, upon whose front and back surface the slipper bears. There are some parts of the slipper which should be figured, such as the amount of surface and sizes of bolts, but there are other parts which are determined by practical considerations, and dimensions such as P, R, O, Q, U, etc. (see table accompanying Fig. 17), can be taken from blue prints of other engines, or from the figures here given.

The dimensions K and L of the bearing surface are determined from the total load coming upon the guide and the allowable unit pressure given by Table VII. The maximum pressure comes upon the slipper when the crank is 90 degrees from the line of dead points. Referring to Fig. 24, it will be seen that when a load $W = A\ E$ acts through the piston rod $A\ A$, and is transmitted to the connecting rod $A\ B$, a load $E\ D$ will come upon the slipper. This load

$$S = W \times \frac{ED}{AE},$$

or, approximately,

$$G = W \times \frac{ED}{AD} = W\frac{r}{l},$$

where $\frac{r}{l}$ is the ratio of the crank length to the length of the connecting rod. This ratio usually is from ¼ to 1/5 for marine engines. The amount of surface for the slipper will then be

$$K \times L = \frac{W \times r}{l \times P}. \qquad (25)$$

The tables under Figs. 17, 18, 19 and 20 will show that K and L are nearly equal in smaller engines, but that $K = 1.5\ L$ in the larger engines. The bolts joining the slipper to the cross-head, and those joining the two parts of the box, must be figured for the load G. The distance from the center line of the piston rod to the surface of the slipper, see Q, Figs. 17 to 20, must be sufficient to have the boxes on the forked end of the connecting rod clear any adjacent parts or surfaces when angled over the extreme amount. The exact distance must be taken from the assembly drawing, but it will generally be from 2.5 D to 3 D.

The cast-iron beam upon which the box guide slides can be figured as a beam supported at the ends, and loaded at the middle with a load G. Its length will equal the stroke of the engine + K. The thickness of the beam M can be assumed from the table, and the beam figured as though of solid cross-section, although it will be cored out inside to permit water to circulate and carry off the heat.

The type of slipper shown in Fig. 18 is the one most commonly used. The amount of surface needed when going ahead is figured in the same way as in the previous case, but as the "backing" surface is upon the back of the slipper, it will be less than the "go-ahead" surface, because of the web joining the slipper to the block flange. The "backing" surface is made as great as possible, but is usually only about two-thirds of the "go-ahead" surface. When backing, there is a tendency for the slipper to break close to the web spoken of, so that it must be figured for bending at that point.

The arrangement of slipper and backing guide is shown in Fig. 25. It is assumed that all of the restraining pressure exerted by one backing guide $= \frac{G}{2}$, is acting at the center of the surface, with an arm $\frac{b}{2}$. The front and back of the slippers are recessed to take white metal, so that the thickness effective for resisting bending will be that between the backs of the white metal. Choosing a stress appropriate for the material of which the slipper is to be made, generally cast or wrought steel, the necessary thickness of slipper between the backs of the white metal will be

$$t = \sqrt{\frac{W \times r \times b \times 6}{2 \times l \times 2 \times K \times f}}, \qquad (26)$$

where W = load upon piston rod,
r = length of crank,
b = breadth of backing surface in one guide,
l = length of connecting rod,
K = length of slipper,
f = a stress which will allow a factor of safety of 12, since the slipper is subjected to loads acting in opposite directions.

The thickness thus found must be increased by the thickness of white metal on each face.

The backing guide can be figured in the same way, by merely changing the allowable stress, as cast iron is usually employed for the backing guide, and it is assumed that only that portion of the guide in immediate contact with the slipper resists the bending; therefore, K has the same value as before. Since the bending takes place where there is a sharp corner, it is well to use a low stress, about 1,500 pounds for cast iron. The bolts attaching the backing guide to the engine frame are spaced from 6 to 8 diameters apart. These bolts are brought into play only when the engine is backing, and it will be assumed that all of the bolts in the guide help to carry the load. This load will be

$$\frac{G}{2} \times \frac{e+g}{g} \text{ (see Figure 25)},$$

the distance $e + g$ depending upon the size of bolt used, and this size will have to be determined by trial. The number of bolts will be

$$\frac{K+s}{n},$$

where K = length of slipper, s = length of stroke, and n = spacing of bolts. These bolts can be placed within a half inch of the edge of the slipper. Therefore,

$$e = \frac{b}{2} + \frac{1''}{2} + \frac{d}{2},$$

where d = diameter of bolt assumed. The bolt should be placed not nearer to the outer edge of the guide than 1.5 d, and the projecting lip will be from ½ inch in small engines to 1 inch in larger engines, so that $g = 1.5\ d + ½$ inch to 1 inch. The effect of placing the bolts so far to one side of the line of action of the force will be to increase the effective load $\frac{G}{2}$ to about G, and this can be kept in mind when selecting the trial size of bolt from Table IV.

When the cross-head block is provided with two slippers, as shown in Fig. 19, there is as much "backing" surface as "go-ahead" surface, and a guide must be provided for both sides of the engine frame. In this case the back of the slipper does not have to be kept open to clear the "backing" guide, so additional webs can be put in, thus making a much stronger and stiffer slipper. Since the slippers are not subjected to bending, they can be made thinner than in the previous case; and the webs, joining the slipper to the flange which connects it to the block, are made thinner than the single web. These thicknesses cannot be figured, but are determined by practical considerations; the parts must be thick enough to "look well," and have the requisite stiffness. The data given with Fig. 19 will be useful in this respect.

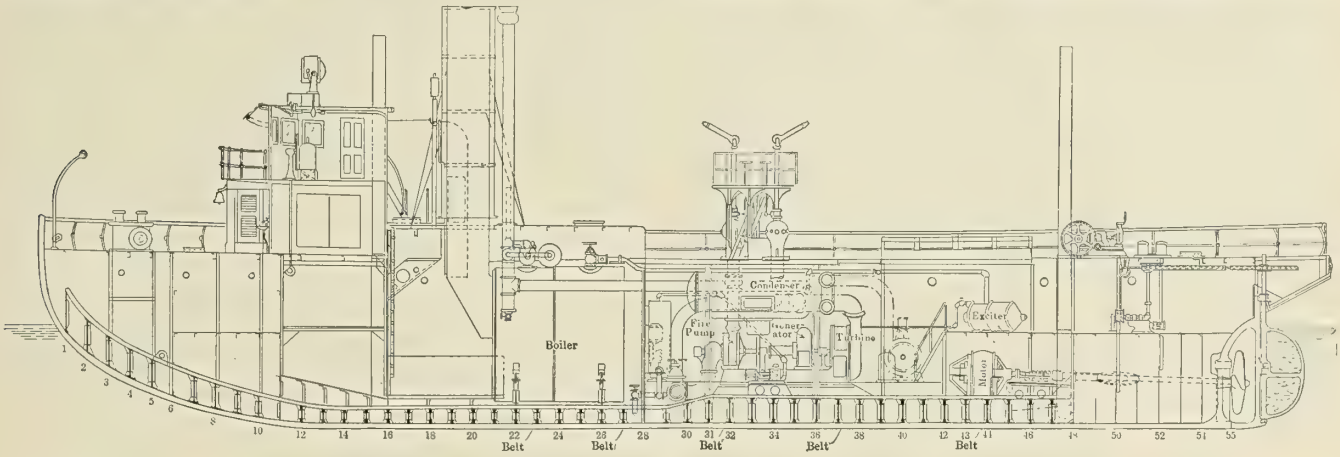
The cross-head shown in Fig. 20 is used on very large engines. The "backing" surface is equal to the "ahead" surface, and all of the parts are designed in the same way as those previously mentioned. This design enables the columns to be placed closer to the center line of the engine, and is used generally with four cast-steel columns to each cylinder, upon each of which is a guide surface.

Upon all of the types of cross-heads it will be noticed that provision is made for removing the slipper without disturbing the alinement of the other parts. The key at the top of the block, which permits this removal, is held in place by two or more bolts. In the "two-slipper" and "four-slipper" type of guide, the bolts attaching the slipper to the block need be only ¾ inch to 1 inch in diameter. In the other types they should be figured to carry the full load coming upon the slipper when backing. The key at one end and the lip at the other prevent any shear from coming upon these bolts.

(To be continued.)

CHICAGO FIRE BOATS.

Designed by W. I. Babcock, New York, two fireboats for the fire department of the city of Chicago have been built by the Manitowoc Dry Dock Company, Manitowoc, Wis., and were expected to be fully completed and go into service by the middle of this summer. For facility in maneuvering in the narrow and crooked river, and in the slips where the boats have to work, they are fitted with twin screws, and also with steam steering gear. By working one screw ahead and the other astern the boats can be swung completely around as on a pivot in either direction.



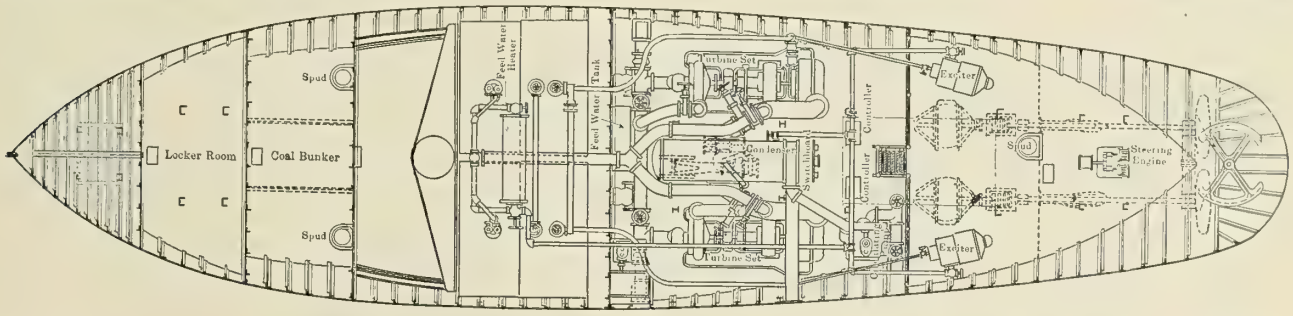
INBOARD PROFILE OF THE CHICAGO FIRE BOATS, SHOWING LOCATION OF PUMPS AND FIRE NOZZLES.

Hulls.—The boats are 120 feet over all, 109 feet 6 inches between perpendiculars, 28 feet molded beam, 15 feet molded depth, and will have a draft of about 9 feet 6 inches. They are constructed of steel throughout, practically no wood being used anywhere except for the inside finish of the deckhouse and pilothouse. The fore foot is cut away considerably, both for convenience in handling and for breaking ice, and the bows at the waterline are heavily strengthened also for the latter purpose. There are five bulkheads, of which four are watertight, and lower decks forward and aft, dividing the hull into six watertight compartments.

discharge, and capable of delivering together 9,000 gallons of water per minute at a pressure of 150 pounds per square inch, when running at a speed of 1,700 revolutions per minute. By branch pipes, properly fitted, the discharge of one pump can be turned into the suction of the other, thereby running the pumps in tandem as one four-stage pump, then delivering 4,500 gallons per minute at 300 pounds pressure. This, going through a 3½-inch nozzle, will make a tremendously powerful and effective stream.

At 125 pounds pressure these pumps will each develop 5,500 gallons per minute. One of the great advantages of the centrifugal pump for this service is that the volume and capacity can be varied at will. Combined with this is a smoothness of operation and lack of necessity for attention not found in any other pump, while if inadvertently all discharge openings are closed at once the pressure would rise but slightly, and there would be no danger of bursting hose or anything else.

Another great advantage of centrifugal pumps operated by steam turbines lies in the fact that the boat can throw her rated capacity of water at all times, and there is a great saving of fuel over the ordinary reciprocating pumps operated with single non-condensing steam cylinders. The water consump-



GENERAL ARRANGEMENT OF PUMPING AND PROPELLING MACHINERY ON THE CHICAGO FIRE BOATS.

With the exception of the engine-room skylight, the low boiler trunk and a deckhouse immediately forward of it containing a toilet and a large hose room, with pilot house on top, the deck is flush. A plate bulwark forward continues back to the deckhouse, from which an open iron rail extends aft, supported by cast steel stanchions. Two lines of heavy iron trough-shaped fenders run all fore and aft on the outside of the hull.

Machinery.—The arrangement of the machinery is novel, in that the same engines are used for operating the fire pumps and for propelling the vessel, thus entirely doing away with separate propelling engines. Each boat is fitted with two centrifugal fire pumps, built by the I. P. Morris Company, of Philadelphia, of the two-stage type, with 14-inch suction and

tion of the turbine per horsepower per hour is only about 17 pounds, while with the reciprocating pump it is probably three times that amount. It is practically impossible to put boilers enough in the boat to supply this amount of steam. Even with the exhaust turned into the stack to force the draft, which means a low efficiency for the boilers, there is probably no fireboat in service to-day, with reciprocating pumps, that can run those pumps to anywhere near their full capacity. A boat rated as of 9,000 gallons capacity per minute is really only about a 6,000-gallon boat.

The pumps are set one on each side of the ship, drawing from a 14-inch header, extending across the engine room immediately forward of them, and delivering to turrets on deck directly above. All connections are short and direct, and all

curves of easy sweep. The deck turrets are set diagonally on deck, and each has nine 3½-inch openings for hose, with quick-moving lever valves at a convenient height. In winter these turrets will be inclosed in iron casings, to which steam pipes are led, to prevent freezing. At a height of about 7 feet above the turrets is an oval platform carrying the two 3½-inch Universal monitors, which are vertically over the turrets and supplied by 5-inch pipes from them. The supports for the platform and the ladder to it come between the turrets, so as not to interfere with the hose lines. There are no other monitors on the boats, Fire Marshal Horan, of Chicago, believing that smaller ones forward and aft are unnecessary.

Each pump is driven by a horizontal Curtis turbine of 660 horsepower, built by the General Electric Company, of Schenectady, N. Y., and directly connected to it on the same shaft and bed-plate. This shaft also carries a 200-kilowatt generator of the direct-current type, shunt wound for 275 volts, for operating the propelling motors. On each of the propeller shafts of the vessel is placed a direct-current, variable speed, reversing motor, shunt wound, and designed for operating on the variable voltage system, developing 250 horsepower at 200 revolutions per minute.

Two turbo-generator exciting and lighting sets of 25 kilowatts capacity each are provided, either of which alone is sufficient. All generators and motors are to be tested by a stream of water from a hose, and must operate perfectly under such conditions. Steam or moisture in the engine room will therefore have no effect on them.

The generators and motors are supplied with independent controllers, two in the engine room and two in the pilot house, with suitable switching devices, so that only one set can be in use at a time. A switchboard is installed in the engine room. Between the two turbine sets, high up under the deck beams, to save floor space, is a surface condenser built by the Alberger Condenser Company, of New York, with wet and dry vacuum pumps directly beneath it. The 10-inch centrifugal circulating pump is on the port side abaft the turbine set. The capacity of this pump is 3,000 gallons per minute, and it is fitted with a bilge suction, so that it can be used for pumping out the engine room in case of necessity. Feed and pony pumps, sanitary pump, etc., are placed on the bulkhead next the boiler room.

Boilers.—There are two Scotch boilers, built by Johnston Brothers, Ferrysburg, Mich., in a compartment next forward of the engine room, placed side by side, facing forward. These boilers are 12 feet 6 inches in diameter, and 11 feet 6 inches long between heads, built for a working pressure of 170 pounds per square inch. In each boiler are two Morison suspension furnaces, 44 inches diameter, with separate combustion chambers. The boilers have one stack in common, and are operated on the closed stokehold system, with blower in engine room.

Operation.—In the operation of these boats, great speed is not required, and therefore the generators and propelling motors are only of moderate power, less than one-half the capacity of the two turbines. The Chicago river is crossed by bridges every block or two, which must be opened for the passage of the boats, so that high speed is out of the question. It was considered, further, that a combination of circumstances requiring full power on the fire pumps and full power on the propelling motors at the same time for any protracted period is practically impossible, and that if, while the boat is pumping water to her full capacity, the motors are called into service to change her position slightly, the turbines will easily stand the temporary overload.

It was for this reason that the electric propulsion was decided upon. The turbines were there, anyway, for the fire pumps. If ordinary steam engines were used for propelling the boat, it meant two more engines, with four cylinders, valves, shafts, rods and all the complication and working parts to take care of and keep in repair. Adding the generators and motors, which practically require no attention at all, added nothing to the work of the engineer, while by the system of control adopted, he is even relieved of the necessity of answering bells and operating engines as usual. All this is done from the pilot house, where the captain has a lever under each hand, and can control his twin screws, going ahead or back on either or both at any speed instantaneously and entirely independently of the engineer, to whom it makes no difference whether the motors are turning or not.

When the boat is lying at her station, under banked fires, waiting for an alarm, the sea cocks are closed and the pumps drained of water. When an alarm comes in the engineer has only to start his turbines, circulating and air pumps. The captain starts the propelling motors, and, on the run to the fire, the power of the turbines is used for running the boat only, the impellers of the fire pumps turning freely in the casings and doing no work. Special arrangements are fitted for oiling the bearings under this condition. On arrival at the fire, all the engineer has to do is, without stopping the turbines, to open the sea cocks and turn water into the pumps. As soon as the propelling motors stop the generators cease to develop power, and the armatures turn freely, the power of the turbines then being used for pumping only. If the motors are called upon temporarily to shift the position of the boat, the action of the pumps is not interfered with.

When the fire is over and the boat relieved, the engineer simply shuts his sea cocks, opens the drains on the pumps, and the boat goes back to her station.

There are important incidental advantages in driving the screws by motors instead of steam engines. One is that if the boat ever has to go into rough water, there is no racing of the screws, the speed of revolution being constant for whatever voltage is being used; this being governed by the controller. It is also possible for short periods to considerably increase the revolutions and power developed by the motors, though this cannot be done for any length of time, on account of undue heating. Another advantage is that, if a sudden strain is put upon the shaft by the propeller striking heavy ice, or running against dock piles or other obstructions which are frequently encountered in the confined spaces in which the boats must work, the circuit breaker throws out, instantly taking off the power, and there is much less danger of breaking wheels or shafts than if a steam engine were used.

The engineer has to answer no bells at any time, and can devote his whole attention to his machinery. Of this the turbines and fire pumps are entirely inclosed, and require no attention at all, while nothing is more reliable or requires less attention than high-class generators and motors. As an additional precaution the extra controllers are fitted in the engine room, and the engineer can operate the motors on signal from the pilothouse as usual if desired.

A full installation of electric lights is fitted, operated by either one of the turbine exciting sets, and a powerful searchlight is fitted on top of the pilothouse.

The Chicago river is in many places 200 or more feet wide, and the buildings extend right to the water's edge. The depth is about 20 feet. Since the opening of the drainage canal to the Mississippi there is at all times a considerable current in portions of the river. In order, therefore, to hold the boats in a position where they can do effective work on a fire at the river bank, where lines cannot be made fast to moor them, they are fitted with spuds like a dredge, two forward and one aft, working through wells in the bottom of the boat and raised and lowered by steam power. These spuds are made of double thick steel pipe, 18 inches diameter, stiffened internally by heavy plates and angles, shod with cast steel points to take hold of the river bottom, and made watertight to reduce the apparent weight to be handled.

Breakdowns.—These boats are exceptionally guarded against total disablement by breakdowns of any single part of the equipment. Nearly everything is in duplicate. There are two boilers, two fire pumps, two turbines, two generators, two screws, two propelling motors, two exciting and lighting sets, two feed pumps and two injectors. While there is naturally only one condenser, circulating and air pump, the turbines are fitted with disabling pipes, through which they can be exhausted to the atmosphere if necessary, so that any accident which puts the condenser temporarily out of service can only reduce somewhat the efficiency of the boat without causing her to be laid up entirely.

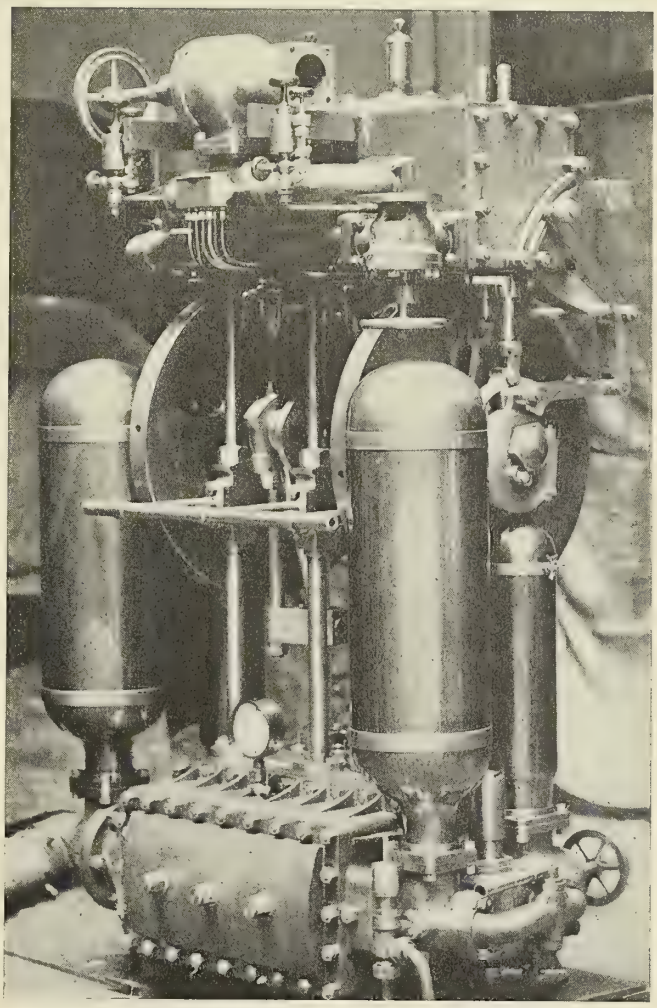
The Float Beta of the London Fire Brigade.

The powerful steam fire pumps and other fire-fighting apparatus on board the *Beta,* the latest and most powerful fire float on the Thames, have been specially designed and constructed by Shand, Mason & Co., of Blackfriars, London. The *Beta* marks fifty years of the Thames floating steam fire engine, and the contractors for the initial steam fire float (Shand & Mason) were the predecessors of the present firm.

The fire-extinguishing output of the *Beta* is furnished by four pumping engines, each of which will deliver 1,000 gallons per minute at a pressure of 140 pounds to the square inch. These engines are so arranged that each can be worked separately, or two, three or four together. The pumping capacity of the float in the latter case is 4,000 gallons per minute or, roughly speaking, 900 tons of water per hour.

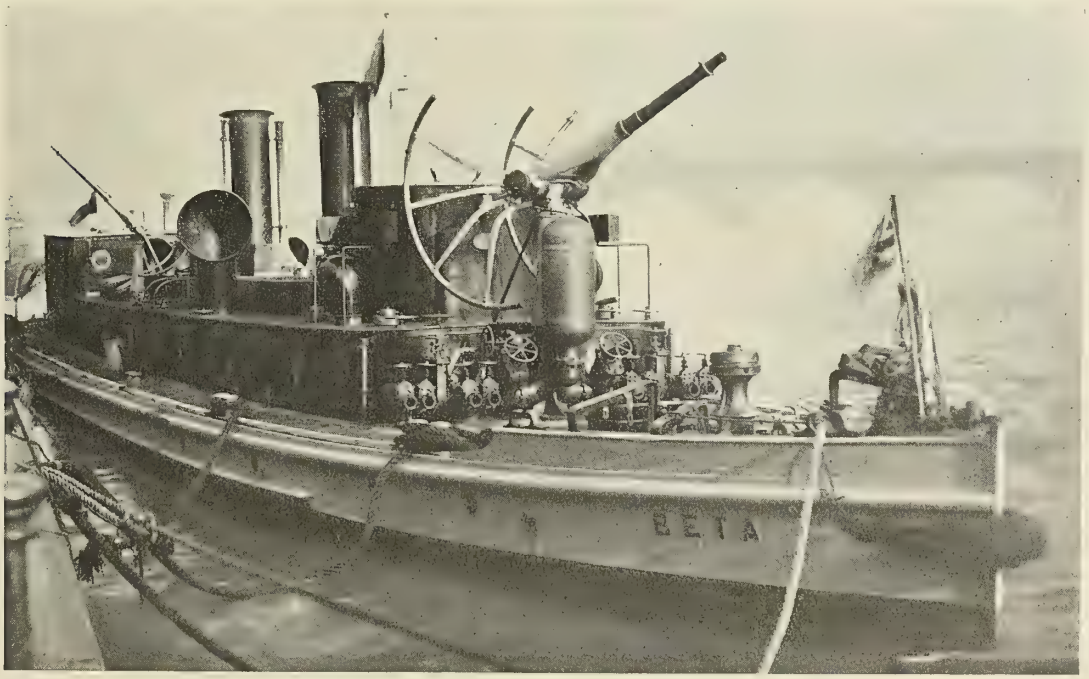
The pumping engines are of Shand, Mason & Co.'s patent double vertical type, giving a uniform delivery of water under even pressure, and are fitted with their variable steam expansion arrangement, this providing the greatest power possible with a given supply of steam. It may be noted that the latest land steamers supplied by the firm to the London Fire Brigade are of similar design to the new *Beta* engines, though, of course, of smaller capacity.

Each engine consists of two double-acting pumps, arranged vertically and connected to a corresponding pair of steam cylinders by stout standards of polished forged steel. Two



FRONT OF ONE OF THE FOUR PUMPING ENGINES.

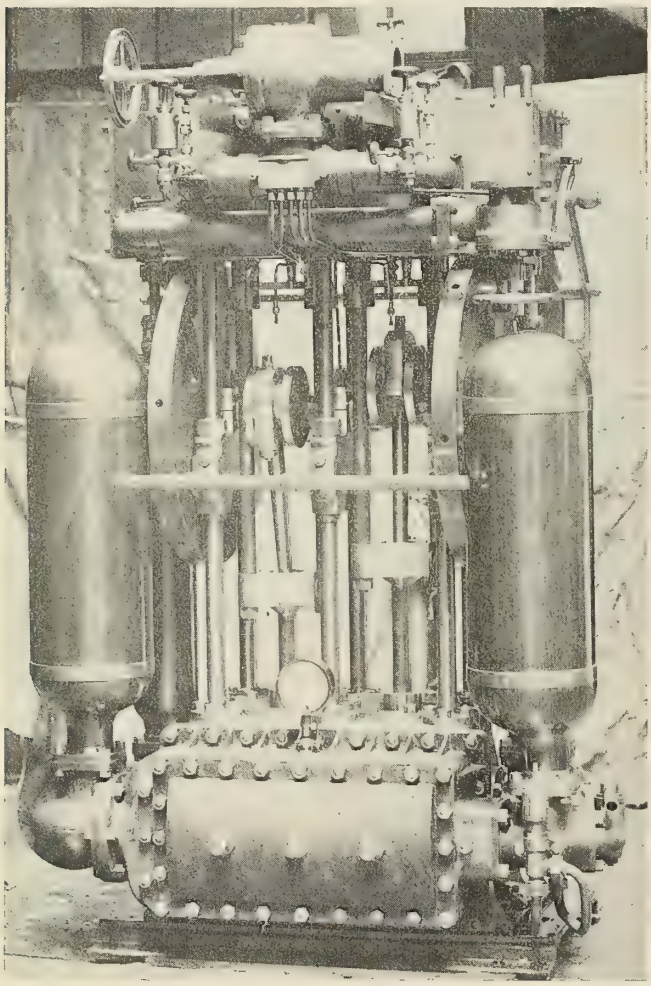
piston rods convey the movement of each piston to the corresponding bronze cross-head, which is made solid with the



THE FIRE BOAT BETA, RECENTLY ADDED TO THE LONDON FIRE BRIGADE, SHOWING BIG MONITOR NOZZLE.
(Copyright, Reginald Haines, London.)

pump-rod, and a steel connecting rod jointed in the cross-head communicates the movement to the double-throw crank-shaft. Suitable fly-wheels on the crankshaft provide for regular working, and at the ends of the crankshaft are the eccentrics of the variable cut-off gear, the variations being effected by means of a lever and quadrant at side of steam cylinder, as shown in one illustration.

The pumps have large valve area, admitting of high speed and steady delivery of water at high pressure. These valves are readily accessible for examination or renewal by removal of one cover. Large copper air-vessels are fitted to suction and delivery branches. An automatic relief valve is



SIDE OF ONE OF THE FOUR PUMPING ENGINES.

fitted in addition to the by-pass connecting delivery and suction chambers, and relieves the pump of any excessive pressure due to the closing of outlets, use of small jets or other cause. The lubricating arrangements and other fittings are of the most complete and up-to-date character.

The fire-engine fittings on deck, supplied by the builders, include a large monitor nozzle of new design, which will take the full combined capacity of the pumps, and through which a powerful stream of water can be hurled a distance of some 300 feet. So efficient is the action of this monitor that notwithstanding the great pressure at which the water is thrown, the 3½-inch or 4-inch jet can be directed to any point or at any angle and controlled with the greatest ease.

Two smaller monitors of similar design to the large one, fitted with 1¾-inch or 2-inch jets, and capable of taking 1,000 to 1,200 gallons per minute each, are also fitted on the deck—one on either side. There are, in addition, eight separate delivery outlets to which lines of hose can be connected and run up into a burning building or vessel, enabling the firemen to deal with a fire at close quarters; or by means of long lines of hose from these outlets the float's pumping power and inexhaustible supply of water may be used with effect a quarter of a mile or more from the waterside, should a large conflagration demand it.

Under ordinary conditions of working, the fire pumps of the *Beta* will, of course, draw their supply from the river by means of a fixed suction pipe, but an attachment is provided for flexible suction pipe, so that the fire float can be used at any time for salvage pumping.

The vessel is a specially designed boat, 100 feet in length over all, and of 16 feet beam, with a draft of 3 feet 3 inches. She has a speed of 11 knots and is propelled by two triple-expansion engines.

A Fire Boat for Genoa.

A powerful fire and salvage boat, built by Merryweather & Sons, London, for the Genoa Harbor Board, is capable of throwing twelve jets simultaneously, the largest single jets being 3 inches in diameter at the nozzle. This enormous stream of water was thrown to a height of about 200 feet.

The vessel is called the *San Giorgio,* has an over-all length of 74 feet, a beam of 16 feet 8 inches, and draft of 5 feet. Power is obtained from two Merryweather quick-steaming boilers, which supply the propelling engines, pumps and auxiliary machinery. The propelling engines are of the double-cylinder, vertical compound type, driving twin screws.

The fire pumps are of the double-cylinder horizontal "Greenwich" pattern, of a total capacity of 4,000 gallons per minute. They draw water from the side of vessel when in use for fire extinction, but when required for salvage operations suction is taken through flexible piping connected to two 6-inch deck connections. The pumps discharge through two monitors on deck, also through two distributing heads, each fitted with four outlets for the attachment of flexible hose. The monitors and pumps are entirely of gunmetal; the steam, exhaust and delivery pipes being of copper with bronze flanges.

In the speed trials of the *San Giorgio* the measured mile at Long Reach was traversed at 10 knots, with the safety valves lifting. A special feature is that the boilers, engines and machinery are all in duplicate, so that the vessel can be practically relied upon as being always in fit condition for service, as, in the event of any part of the installation requiring attention or adjustment, the corresponding relay can be at once utilized. By means of an oil-fired heater, a low pressure of steam can always be maintained in one of the boilers, enabling the vessel to get under way within fifteen minutes of an alarm. Steam at 120 pounds pressure can be raised in twenty minutes from cold water.

The accompanying table gives a list of fire boats at present in service in the New York City fire department:

Name	Length Overall.	Breadth.	Horse-power.	Capacity of Pumps.*
Zophar Mills	120	25	575	....
New Yorker	125	26	800	13,000
David A. Boody	106	23.9	240	6,500
Wm. L. Strong	111	24	338	6,500
Abram S. Hewitt	117	24	649	7,920
Geo. B. McClellan	112	24	650	6,000
Seth Low	99	23.9	265	3,500
James Duane	131	27	850	14,000
Thomas Willett	131	27	850	14,000

Another fire boat, slightly smaller than the *Duane* and *Willett,* is being built for the city. She is named *Cornelius W. Laurence.*

* Gallons per minute.

The Disappearance of Manila Lines on Board Ships.

BY ROBERT SANFORD RILEY.

So closely has manila rope been associated with ships, that it has become a symbol of things nautical. It may surprise some to know that there are now ships with practically no manila or hemp lines aboard. We have become accustomed to horseless carriages, wireless telegraphy, and now we are confronted with "ropeless ships." In the old days fiber ropes were universal, but now the age of steel has come, afloat as well as ashore, and the familiar ropes of manila or other fiber have given way to wire cable. It is some years since steel came into general use for standing rigging; now it is superseding manila even for the running rigging, as well as all other uses aboard ship.

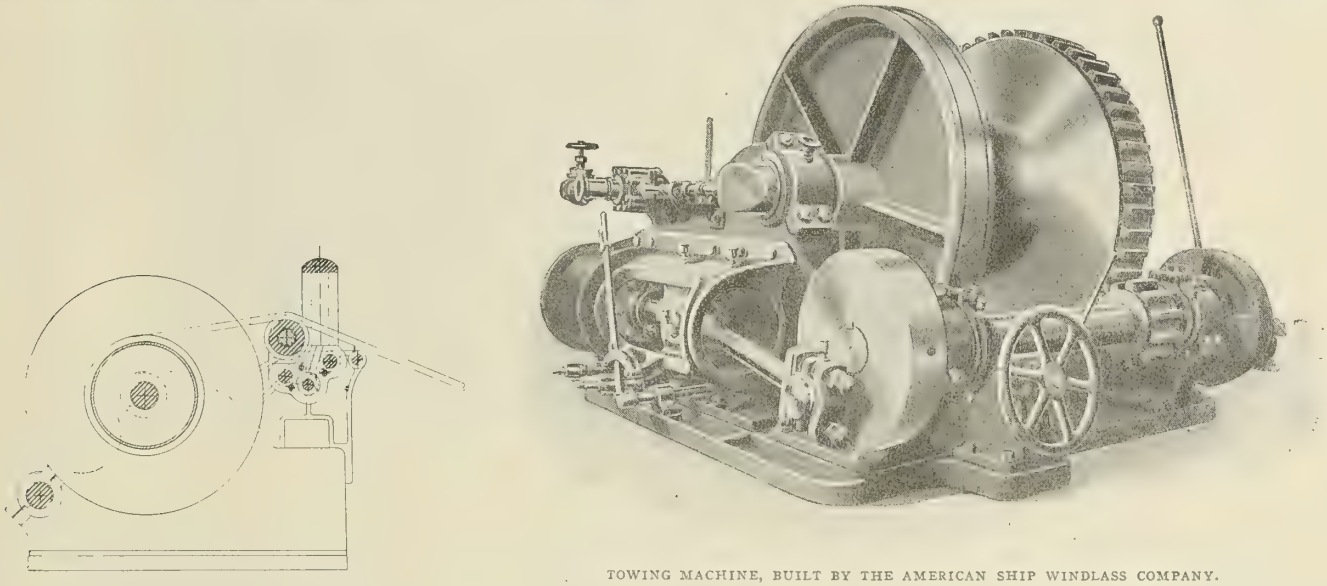
The steering gear is no longer connected up by manila lines, nor even by clumsy and noisy chains. The wire cable makes an ideal connection, being both strong and noiseless. Hoisting lines for all purposes are now regularly made of steel wire cables. The steel ash handling lines do not burn or dry out with intense heat. All the freight elevators and the new passenger elevators aboard ship are operated by wire cables. The awning on deck is strung on wire lines, and the life lines everywhere are generally made of steel.

There are some uses to which wire cables have not yet been adapted, and perhaps never will be. We still depend on stout stud link chains for the most vital of all lines, the anchor cable. The steel cable cannot yet stand such chafing and abuse and still be so dependable as the chain cable. Nor can it safely lie so long unused and uncared for in damp chain lockers. But even in this respect it is better than fiber, for though it will rust it will never rot, and neither will it deteriorate in the hot places so common on steamships. There are many instances where fiber lines have actually rotted and become useless without ever being used. They are bulky and difficult to stow neatly, hence they are apt to be neglected and abused.

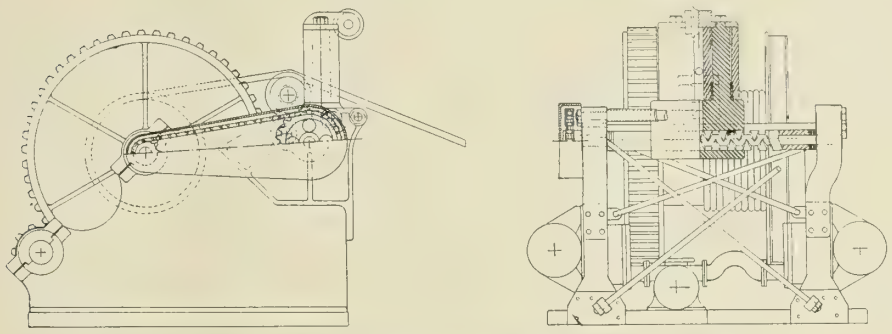
A wire line can be oiled and preserved indefinitely, and its easy stowing qualities are more apt to secure proper treatment for it. It is generally reeled on drums, which are thoroughly accessible and ready at all times for instant use or overhauling. A corresponding manila line would be dumped into some dark corner or locker, so as to keep it out of the way.

The greatest limitation for the use of steel rope is its rigidity. It will not stretch to any appreciable extent, and this renders it very susceptible to sudden shocks. Fiber will stretch before breaking, so that in case of a load suddenly applied it may "fetch up" gradually enough to save parting. This may be illustrated by figures: If a slow-moving ship is brought up with a manila line, it will probably stretch the line 6 inches or more, and during the stretching the ship is gradually losing way. The shock is absorbed in 6 inches, and the momentum may be considered as divided by the distance traveled. In the case of a steel cable, however, the ship would have to be brought up almost instantaneously, say in ⅛ inch; hence, the stress on the rope would be 48 times as great. This shows very clearly that, although the wire may have several times the strength of the manila for a steady pull, yet it has very little chance when it comes to a shock.

The many advantages of wire over manila, however, have led to the adoption of ingenious means for taking care of



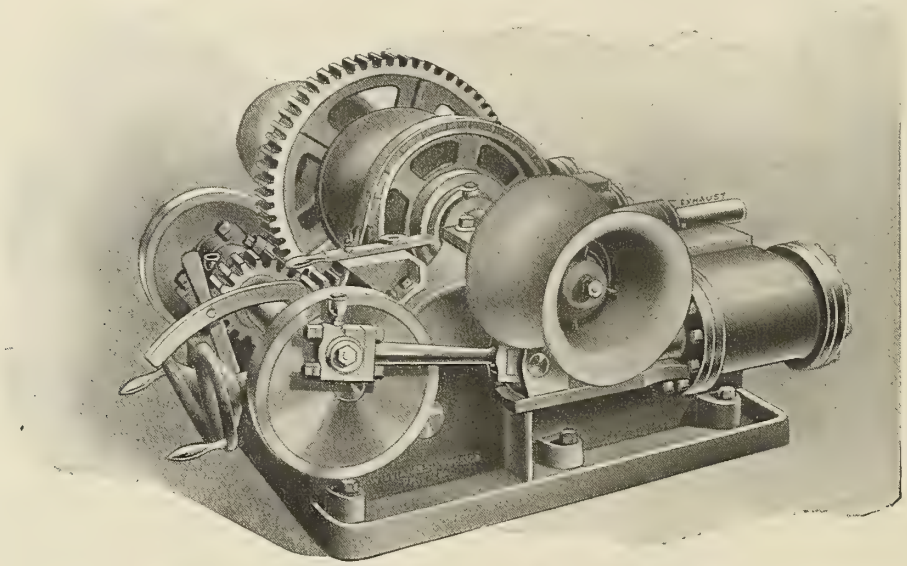
TOWING MACHINE, BUILT BY THE AMERICAN SHIP WINDLASS COMPANY.



PROVIDENCE TOWING MACHINE, WITH PATENT AUTOMATIC WINDING DEVICE.

the shocks which cannot be avoided in handling ships. Incidentally, other advantages are obtained, chief of which are ease and speed of stowing. The lower cost and longer life of wire also appeal strongly to owners.

Perhaps the latest and most interesting elimination of manila is in the mooring of the large lake ships. Doubtless many deep-sea sailors, both in this country and abroad, are not aware that many big American lake freighters are now moored exclusively with wire cable. To do this the ships are equipped with "mooring machines." A mooring machine is simply a hoisting engine, with a drum for wire cable so arranged that the cable may be made fast and steam



MOORING MACHINE, BUILT BY WILLIAMSON BROTHERS COMPANY.

left turned on so as to maintain a steady pull on the cable. The cable serves as a breast or stern line in the usual way. It runs through fairleads at the rail back to the mooring engines, which are generally located nearly amidships. Should any sudden move occur, the cables will overhaul the engine against the pressure of the steam. The ship, therefore, is free to rise and fall, or otherwise accommodate herself to different conditions of load or tide. At the same time she is held in place without attention to the lines.

With the old method of mooring it is generally the duty of the mate or boatswain to stand by to see that the lines are slackened or taken up as required. So, in addition to cheapness and convenience, the machine automatically relieves the mate of his job of watching the lines. Of course, when ready to shove off, instead of the laborious hauling in of lines, a deck-hand simply moves the valve and the cable is neatly and speedily stowed where it bothers no one until required for use again.

Perhaps, however, the most important elimination of manila lines is in connection with the use of automatic steam towing machines. This is another American innovation of some years' standing, and is just beginning to be recognized and adopted abroad. All seagoing men are familiar with the advantage of using a towing machine instead of the old method of rigid connection between vessels at sea. This machine practically causes the line to pull against a steam cushion. If the pull becomes excessive the engine is overhauled; this opens an automatic valve, which admits more steam until the pressure is equalized and the engine begins to haul in again. Then, as the machine recovers the line, the valve is automatically closed until the line comes to rest at its normal position. It is a very simple device, and ideal for the purpose. Even in towing the drydock *Dewey* it was officially reported that the line came to rest exactly the same each time. The machine has made possible feats of towing which would not be thought of otherwise. It is a significant fact that nearly all towing companies who carry their own risks use towing machines.

The original development of the towing machine by the American Ship Windlass Company, of Providence, R. I., was the result of the demand for an elastic connection for towing vessels at sea. The idea of eliminating manila lines was not uppermost, and the wire cable was used simply because of its much greater convenience. Recent developments in the price of manila and labor, however, and the scarcity and uncertainty of both, have led to a new idea of the utility of towing machines. They still stand as absolute necessities for deep-sea towing, but further than this they are becoming recognized as great labor and time savers in the handling of lines. This is accomplished by having an ordinary reverse valve and lever, entirely separate from the automatic valve. It is thus possible to handle the machine as an ordinary winch or capstan, with the added advantage that the wire line is automatically taken care of by the machine itself. A newly-patented automatic reeling device lays the line as neatly and smoothly as on a spool of cotton. This, of course, saves the line from the severe bending it receives, even on an ordinary towing machine, where the reeling is left to chance or the tender mercies of a deck hand.

These new machines make possible the use of wire cable to such an extent that they are now regarded as lucrative investments rather than an equipment for special service. This is because wire lines cost less than manila, and last six or eight times as long. Harbor tugs are beginning to use them very extensively, especially in scow service. The enterprising dredging companies find that they can speed up their service very materially, simply by having a towing machine do the work of indifferent deck hands or firemen. The machine handles the lines so much more quickly that it is frequently possible to get in an extra trip a day, and in bad weather they keep right on towing instead of being obliged to lay up altogether. The old manila lines frequently parted, and were a continual source of expense and anxiety. Some of the up-to-date dredge outfits have no manila lines on board. They use mooring machines on the dredges and towing machines on the tugs, and claim a great saving in all respects. The present tendency is for this practice to become universal wherever possible. In this, as in many other things, the Great Lakes of America have set the fashion for dividend-paying innovations.

THE ANTONIO LANASA ASHORE OFF HATTERAS.

to land on the beach. The rescuers stood by twenty-four hours, until the sea calmed down, when anchors and cables were laid from the steamer's port bow, and a 12-inch hawser to the *Rescue*. At the next high tide the ship's bow was moved off shore a few feet, but it was not until the cargo was jettisoned to lighten the vessel that she finally came off by degrees on April 11. She was towed to Norfolk for repairs.

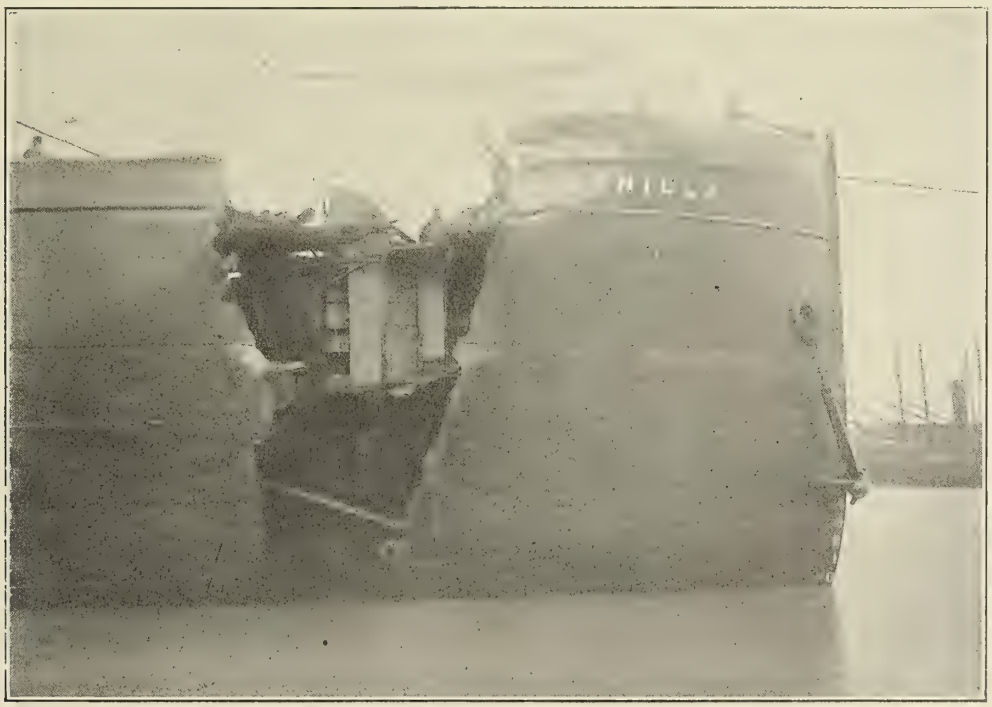
The *Lanusa* was built last year by the Grangemouth & Greenock Dockyard Company, and measures 230 feet in length, 33 feet in width and 20 feet in depth. She is of 813 tons net and 1,261 tons gross. She is divided by watertight bulkheads into five compartments, and is electric lighted. The single screw is operated by a triple-expansion engine, with cylinders 19, 30 and 50 inches in diameter, and a common stroke of 33 inches. Steam is furnished by Scotch boilers operating at a pressure of 180 pounds per square inch. She hails from Bergen.

A Double Collision.

The steamer *James Joicey* collided with two different ships last Feb. 8, at night, just off the Yarmouth Roads. They were the *Syria* and the *Coronilla*. The photographs show that all three ships received considerable damage. All had to be brought to Yarmouth for repairs.

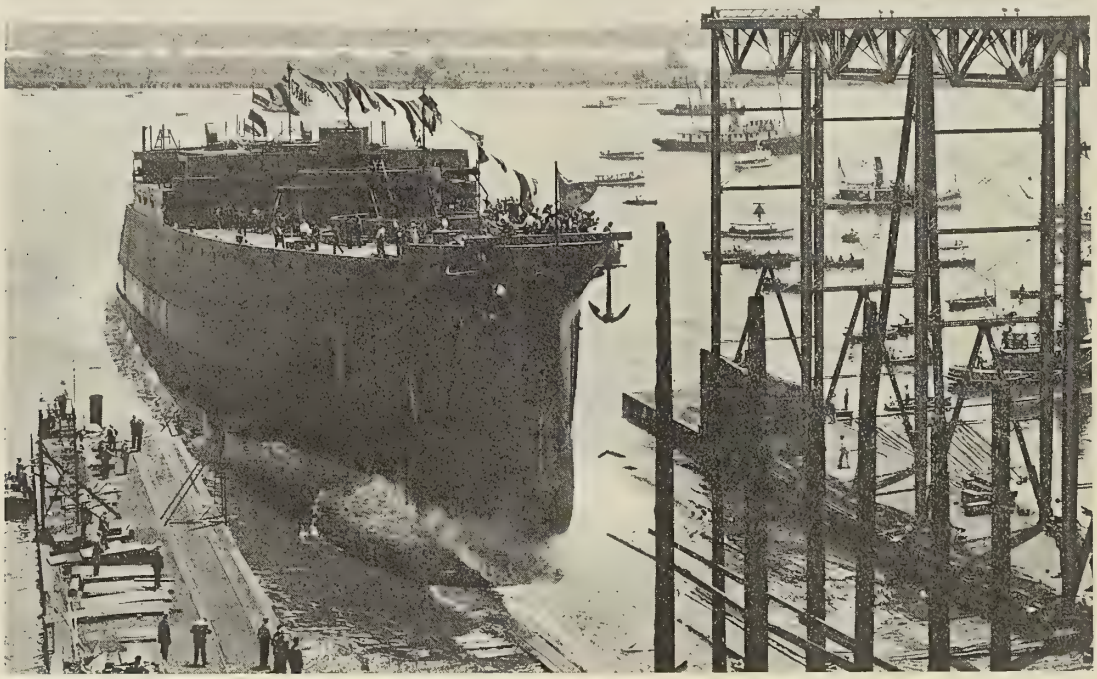
BOW OF THE JAMES JOICEY, SMASHED BY COLLISION.

The *James Joicey* is an iron schooner, with three masts, built by Palmer Bros., Newcastle, in 1863, and is owned by W. Cory



THE HOLE CUT IN THE SIDE OF THE STEAMER CORONILLA BY THE JAMES JOICEY.

The manufacturers of auxiliary machinery in America have always maintained a high standard, and their apparatus is known all over the world for its efficiency and labor-saving qualities. This is perhaps even more evident in the case of auxiliary machinery than in the ships themselves, although no one will dispute the excellence of the lake-built ships for their special purpose.



THE BATTLESHIP SOUTH CAROLINA, LAUNCHED FROM THE CRAMP SHIPYARD INTO THE DELAWARE RIVER.
(Photograph, Wm. H. Rau.)

The Battleship South Carolina.

On July 11 the second of the American "all big gun" battleships was launched by William Cramp & Sons, Philadelphia. This ship, which is a sister of the *Michigan,* launched in May, has a length of 450 feet on the waterline; a beam of 80 feet, molded; and a mean draft of 24 feet 6 inches. The displacement on this (trial) draft is 16,000 tons, while the full load displacement is 17,617 tons. Propulsion is by means of two four-cylinder triple expansion engines driving twin screws. The cylinders measure 32, 52, 72 and 72 inches in diameter, with a stroke of 48 inches. Steam is furnished by twelve Babcock & Wilcox watertube boilers at a pressure of 265 pounds to the square inch. These boilers have a total grate surface of 1,050 square feet, and a heating surface of 47,220 square feet, the ratio being 45 to 1. The designed indicated horsepower is 16,500, corresponding with a trial speed of 18½ knots. The normal coal supply of 900 tons can be increased to a maximum of 2,175 tons.

The main point of interest lies in the battery and its arrangement. There are eight 12-inch guns of 45 calibers, mounted in pairs in four turrets, all on the center line, the two inner turrets being raised above the end turrets, so that four guns may be fired forward, four aft, and the entire eight on either broadside. Each turret has an arc of fire of 270 degrees. The first and third turrets, counting from the bow, have their gun axes about 24 feet above the waterline. The second turret shows an axis of 32 feet above the line of flotation, while the after turret has its guns 16 feet above the water. The secondary battery includes twenty-two 3-inch guns; two 21-inch submerged torpedo tubes, and fourteen automatic guns. The broadside from the eight main guns is 6,960 pounds at one discharge, comparing with a broadside of 6,800 pounds for the *Dreadnought,* 7,000 pounds for the *Satsuma,* 6,790 pounds for the *Danton,* 9,120 pounds for the *Delaware,* and 9,912 pounds for the *Nassau.*

The waterline belt of armor extends from bow to stern. It is 8 feet wide, of which about 5 feet is below the normal waterline. The maximum thickness is 11 inches, tapering to 9 inches at the bottom. Above this belt, and covering the side for about 300 feet, is an upper belt, 10 inches thick at the lower edge and 8 inches at the upper, with 10-inch bulkheads running across the ship at the ends. The barbettes for the turrets are 10 inches on the face and 8 inches in the rear, while the turrets themselves are 12 inches in front and 8 inches in the rear. A conning tower 12 inches thick is fitted just aft of the second turret, and is provided with a 9-inch tube, protecting communications to the interior of the ship. The protective deck has a thickness on the slopes of 3 inches, and is 1½ inches thick forward.

The ships were authorized March 3, 1905, and contracts for construction were let in July, 1906. The keels were laid in December, 1906, and the contract calls for completion late in 1909. The contract price of hull and machinery for the *South Carolina* was $3,540,000 (£727,422), and for the *Michigan,* $3,585,000 (£736,670). In each case the cost of the completed vessel will be about $7,000,000 (£1,440,000).

Stranding of the Antonio Lanasa.

Early in the morning of March 23 the Norwegian freight steamer *Antonio Lanasa,* heavily laden with bananas, oranges and cocoanuts from Jamaica for Baltimore, went ashore on the south side of Cape Hatteras, in a southeast storm. The life-saving crew, working all day, succeeded in landing nine men, but the others, including Capt. Thomel and his wife, declined to go ashore, as a heavy sea was running at the time.

The wrecking steamer *Rescue,* of the Merritt & Chapman Derrick & Wrecking Company, reached the scene the following morning, but the sea was so high as to make it dangerous

THE HOLE IN THE SIDE OF THE SYRIA, AFTER COLLISION WITH THE JAMES JOICEY.

& Son, Ltd., London. Her gross tonnage is 731 and net 443. Her dimensions are: Length, 200 feet 6 inches; beam, 28 feet, and depth, 16 feet 8 inches. The triple-expansion engine has cylinders of 16, 26 and 43 inches, with a stroke of 36 inches. The boiler pressure is 150 pounds per square inch.

The *Syria* is an iron screw steamer, built by Raylton Dixon & Company, Middlesbrough, in 1889, and is owned by Thomas Wilson, Sons & Company, Ltd., Hull. Her gross tonnage is 2,239 and net 1,430. Her dimensions are: Length, 277 feet; beam, 38 feet 2 inches, and depth, 19 feet 2 inches. The triple-expansion engine has cylinders of 21, 34 and 56 inches, with a stroke of 39 inches. The boiler pressure is 160 pounds per square inch.

The *Coronilla* is an iron screw steamer, built by the Tyne Iron Shipbuilding Company, Newcastle, in 1878, and is owned by the Tyneside Line, Ltd. Her dimensions are: Length, 258 feet; beam, 32 feet, and depth, 21 feet. Her gross and net tonnages are, respectively, 1,312 and 822. She is propelled by a compound engine with cylinders 28 and 54 inches diameter by 33 inches stroke. The boiler pressure is 75 pounds per square inch.

James Fisher.

The Launching of the Tug Patuxent.

BY R. P. SCHLABACH.

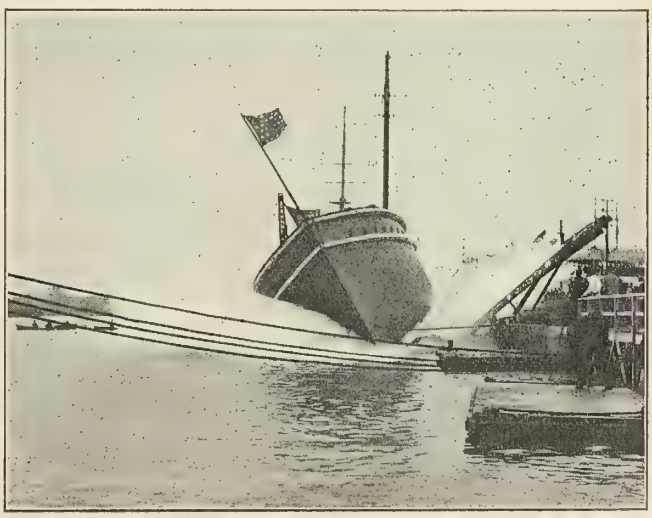
An interesting and rather unusual launching took place at the navy yard, Norfolk, Va., on May 16, when the tug *Patuxent* was put overboard for her initial plunge. She is a twin-screw, sea-going tug built of steel throughout, of the following dimensions:

Length, over all.....155 feet 9 inches.
Breadth, extreme ..... 30 feet 2½ inches.
Draft, full load..... 14 feet ¼ inch.
Displacement, full load.....917 tons.

Her complement is to be 37 officers and men. She will be electric lighted and will be provided with a wireless outfit.

The *Patuxent* was laid down on ways running parallel to the sea wall, and the keel blocks are about 18 feet from the edge of the wall. To facilitate handling of material, a gantry crane of wood was constructed and an electric hoist fitted for same. Before launching it has been the custom to run the crane to one end and to remove all the supports on the water side except the two at one end, on which the crane is resting. In the present case, however, as the construction of no other vessel at this yard is authorized, the entire crane structure was removed.

The top of the sea wall was about five feet above the water at the time of launching, and as it was not practicable to run



THE LAUNCHING OF THE NAVY TUG PATUXENT.

the ground ways out into the river, it was necessary to drop the tug rather than slide her into the water. Six ground ways were provided; these ways were 15 inches wide and extended about 12 feet beyond the edge of the sea wall. About 25 feet from the outer end these ways were cut and scarfed to allow them to tip. These outer ends were well secured and shored to prevent their getting out of line with each other. Ribbands were fitted on both sides of the ways to prevent any tendency of the vessel to slew while sliding.

Cradles were fitted on the sliding ways, and the latter were well tied and cross-braced, so as to make a single cradle for the whole vessel. These sliding ways were 12 inches wide by 25 feet long, and the total bearing surface was thus 150 square feet. The weight of the hull at launching was 200 tons, and the weight of the sliding ways was 14 tons, the total launching weight being 214 tons, or 1.73 tons per square foot. At the time of launching, the hull was complete up to the main deck, but there was no machinery aboard, nor was the deck house in place.

The sliding ways were sufficiently weighted to insure sinking immediately and thus avoid any danger of injuring the vessel on any of the heavy timbers. Two triggers were fitted, one at each end. One end of the trigger was held by a chock on the end ground way, and to the other end was secured a line and tackle. About a foot from the end next the ground way was a shore running to the sliding way. A heavy strain was put on the lines, and by cutting both lines simultaneously the vessel was released and launched. Hydraulic jacks were set up hard against the inboard side to insure the vessel's starting when the lines were cut.

The tug took the water very easily and did not heel more than forty degrees, the main deck remaining perfectly dry. She righted herself at once and did not even take up the strain on the mooring lines, not having moved more than forty feet from the sea wall.

ON THE SIZE OF BATTLESHIPS.*

BY SIDNEY GRAVES KOON.

Much has been written recently regarding large battleships and their great adaptability to uses where smaller ships could be employed only with large increase of numbers. In general the discussions have dealt almost wholly with the question of gun power, and have either ignored the physical relations between large and small ships, or have covered them by implication only. It is proposed to take up a representative battleship, such as the *Michigan* in the United States navy, and to institute a number of comparisons between this ship and two ships, each of half the displacement of the *Michigan,* but designed under varying conditions so far as the principal military features are concerned.

In the first place, a design might be evolved in which the various percentages of weight used for the several elements constituting the displacement of the *Michigan* might be retained in the smaller vessels. A second design would call for the same battery as the first, the same speed as the type ship (*Michigan*), and such armor protection as might be available after making due provision for these other two features. A third design calls for the same battery as the first, and for protection equal to that given the *Michigan,* with such speed as can be obtained in connection with this battery and armor. The fourth design calls for the same speed and protection as in the *Michigan,* and for such battery as may be obtained after making provision for the other two items.

While the weights allotted to the various component portions of the *Michigan* are not public property, and cannot, therefore, be given with any exactness, yet a sufficiently close approximation for our purpose can be made, and whatever errors there may be in this statement of weights will by no means vitiate the comparison instituted. A schedule of weights assumed for the *Michigan* is given; this accounts for the total displacement of 16,000 tons.

	Tons.	Tons.*
Hull and fittings complete	6,400	*7,469*
Equipment and stores	800	*823*
Battery and ammunition	1,300	*1,118*
Protective deck	900	*in hull*
Vertical armor	4,200	*4,047*
Machinery and water	1,500	*1,643*
Coal	900	*900*

The *Michigan* has a length on the waterline of 450 feet, a beam molded of 80 feet, and a draft of 24 feet 6 inches. She is propelled by twin screws, the horsepower of the machinery being designed as 16,500, and the designed speed, 18.5 knots. The battery consists of eight 12-inch guns mounted in pairs in four turrets on the center line, in such a way that all can be brought to bear on one broadside. The secondary battery includes twenty-two 3-inch and fourteen smaller guns, besides two torpedo tubes. The protection includes a waterline belt with a maximum thickness of 11 inches, upper belt with maximum thickness of 10 inches, turrets and barbettes with thickness of 8 to 12 inches, and a protective deck with a maximum thickness of 3 inches.

The ratio between the length of one ship and the length of a ship of similar shape and half the displacement is 1 to 0.7937. Applying this ratio to the dimensions of the *Michigan,* we have for each of our smaller ships a length of 357 feet, a breadth of 63 feet 6 inches, and a draft of 19 feet 5 inches. Our first ship would have a schedule of weights, each item of which would be just one-half the corresponding item for the *Michigan,* as shown in the table for weights under the four different designs. This ship would, of course, have just half the *Michigan's* battery, namely, four 12-inch guns, eleven 3-inch, seven smaller and one torpedo tube. Its armor protection would cover the same proportionate area as that of the *Michigan,* each linear dimension, however, being proportionate to the corresponding dimension of the *Michigan,* in the ratio above given. This same ratio would affect the thickness of the armor everywhere, and the 11-inch belt would become 8.73 inches thick; the upper belt would have a maximum thickness of 7.94 inches; the turret and barbette armor would vary from 6.36 to 9.54 inches; while the maximum thickness of the protective deck would be 2.38 inches, in place of the 3 inches in the *Michigan.*

Not only would the armor be thus decreased in value as compared with the *Michigan,* but the speed would also be decreased, due to the fact that it is physically relatively more economical to propel a large vessel than a small one. This fact may be brought out by analyzing the expected speed performance of the *Michigan* by means of the Admiralty formula:

$$V^3 = \frac{H \times K}{D^{2/3}},$$

where V is the speed in knots; H is the indicated horsepower; D is the displacement in tons, and K is a coefficient of performance known as the Admiralty coefficient, and used for designing purposes. $D^{2/3}$ for the *Michigan* is 635; for each of the other vessels under consideration it would be 400; V^3 for the *Michigan* is 6,332; H for the *Michigan* is 16,500; K

* *The Engineering Magazine.*

* Later:—Figures in italics are believed to be correct.—Editor.

thus becomes 244. As the new ship has the same form as the *Michigan,* we may, without sensible error, assume that this same coefficient, 244, may here be used. On applying this to the formula, knowing that our horsepower is 8,250, we find that *V,* or the speed, becomes 17.14 knots, in place of the *Michigan's* 18.5 knots.

The second design calls for the same speed as the *Michigan,* namely, 18.5 knots. In this case, by using our formula, we find that the horsepower required is 10,380. This raises the weight necessary to be devoted to machinery from 750 tons to 944 tons. As the battery of this ship was to be unchanged, and the armor protection to be so adjusted as to fit the new conditions, the difference of 194 tons must be taken out of the provision for protective deck and vertical armor, thus reducing these two items to 416 and 1,940 tons, respectively. Assuming that each portion of the vessel is covered with armor of the same area as before, but of thickness reduced in the ratio of the weights allotted to armor, we find that the belt has been reduced from the original 11-inch maximum to 8.07 inches; the upper belt is reduced from a maximum of 10 inches to 7.34 inches; the turret barbette armor from 8 and 12 inches to 5.87 and 8.81 inches, and the protective deck from a maximum of 3 to 2.2 inches.

The third design uses the same armor schedule as in the *Michigan,* both as regards actual thickness and proportion of ship protected. This results in increasing the weight required for protective deck from 450 tons, under design 1, to 567 tons, and for the other armor from 2,100 tons, under design 1, to 2,646 tons. This total increase of 663 tons is made at the expense of the propelling machinery, the weight allotted to which thus becomes reduced to 87 tons. This accounts for only 957 horsepower, or a speed, from our formula, of only 8.35 knots. This shows what a very great diminution of speed must be expected if we are to retain in the smaller ship the same relative battery power and protection as in the larger.

The fourth design calls for the same speed and armor protection as in the *Michigan,* and the difference in weight is taken from that allotted to the battery. As found in the second design, the required horsepower is 10,380, calling for 944 tons of machinery. The armor weights will be the same as in the third design, namely, 567 tons for the protective deck, and 2,646 tons for the other armor. As we have made no change, throughout the series of designs, in weights of hull and fittings, equipment and stores and fuel, we still have for these items a total of 4,050 tons. Adding this to the above-mentioned figures for machinery and protection, the total becomes 8,207 tons, or 207 tons more than the designed displacement of the vessel. This means that, in order to float at the designed displacement with the same structure and equipment, an amount equal to 207 tons would have to be taken bodily from the vessel, or stores, or both; and it means, moreover, that there would be absolutely not one pound available for the provision of a battery of either heavy or light guns. Of course, it will be recognized that we have appropriated all the necessary weight for a splendid protection to such a battery, and that no designs would ever be evolved in which such protection would be provided without allowing for the battery itself. These figures have been worked out, however, simply for the purpose of showing the immense sacrifices which have to be made in various directions in small vessels, in order to provide along other lines qualities similar to those obtained in vessels of larger size.

Item.	Type 1.	Type 2.	Type 3.	Type 4.
Hull and fittings.....	3,200	3,200	3,200	3,200
Equipment and stores..	400	400	400	400
Battery and ammunit'n.	650	650	650	—207
Protective deck.....	450	416	567	567
Vertical armor.....	2,100	1,940	2,646	2,646
Machinery and water..	750	944	87	944
Fuel	450	450	450	*450

* Reduced to 243 on account of deficiency for weight of battery.

The figures above deduced show that under a given set of conditions the two small vessels, having the same total battery power as the one large, would require these sacrifices to be made along other lines:*

If there is the same proportionate weight for armor, there will be a sacrifice in the thickness of armor, amounting to nearly 21 percent; there will be a sacrifice in the speed amounting to about 8 percent. If the total battery power is to be the same, and the speed is also to be equal to that of the large vessel, there will be sacrifices in the armor protection, the reduction in thickness being about 27 percent. If the total battery is to be the same, and the armor protection equal to that of the large vessel, the sacrifice in speed will be tremendous—in fact, markedly greater than would ever be permitted in any design. The falling off would be more than 10 knots; that is, about 55 percent. If we have the same speed and the same protection for the two smaller ships that we have in the larger, there will be no weight available for battery, and our fuel supply will be cut off more than 45 percent.

This line of reasoning shows that there are other reasons besides those of mere gun fire which militate in favor of large ships as compared with small ones. If it were a question of gun fire alone, we might consider that a ship similar in design to the original monitor might be the ideal; for a fleet of such ships could bring all their guns to bear at any point of the compass, because the monitor had a practically unobstructed range of fire all around the horizon. As ships increased in size, demands came for a larger armament, and double-turreted monitors were the answer to the demand. The *Michigan* is the next in this direct line of development, although there have been many, many changes between. The double-turreted monitor design has had added to it a battery of broadside guns, only one-half of which in general could be brought to bear upon one broadside at a time. In the *Michigan,* however, we have gone back in general principle to the double-turreted monitor, carried one step further, for each of the four turrets has command over about three-fourths of the horizon. The small ships represented in the above figures would naturally be provided with two turrets each, instead of the four in the *Michigan,* and would have the same relative command of fire as in the latter ship. Whatever other battery is fitted in accordance with the above figures would be solely for the purpose of discouraging torpedo boats from too much inquisitiveness, and does not affect the general type evolved.

It has long been recognized that every man-of-war represents a compromise between conflicting military interests, and the science of naval architecture has not yet developed an ideal relationship between these interests, nor will it probably ever be reached. For some reasons, speed is an almost paramount consideration, while for other purposes the one item of prime importance is battery power. In either case a certain amount of the one must be associated with the other; for the speed is of no avail unless the battery be at hand to back it up, and the battery is of slight value unless the speed be sufficient to place it within reach of the enemy. Protection and battery go largely hand in hand, an increase in the latter calling usually for a corresponding increase in the former. This is not the case in extreme types, but it is a general principle. In all ships, however, certain sacrifices of one element have to be made to meet demands for excessive provision in another, and in no ship is this sacrifice more marked than in that of small size.

* The whole discussion presupposes that factors of safety are unchanged, and that the same type of machinery and fittings is employed in the small ships as in the large one.

The Largest Steamship Companies of the World.

BY SIDNEY GRAVES KOON.

Much interest centers in the large steamship companies, partly by virtue of the fleets of steamers which they operate, and partly because of the fact that this one or that one is frequently referred to as being of pre-eminent size. We have prepared some tables based on lists given in the 1907-08 edition of the Bureau Veritas, and showing all of the steamship companies of the world which have steamers of an aggregate of more than 80,000 tons gross. There are no less than sixty-nine of these companies, to which list we have added six, two of them because they possess steamers of upwards of 10,000 tons, and the other four because they are the largest companies operating, respectively, under the Brazilian, Chinese, Swedish and Turkish flags.

The first table shows seventeen companies having upwards of 200,000 tons in steamships of more than 100 tons each. Nine of these companies are British; three are German; two are French; one American; one Japanese, and one Italian. At the head of the list is the Hamburg-American Steamship Company, with 847,374 gross tons. The North German Lloyd Steamship Company stands second, being more than 200,000 tons behind the leader. The first British company is the British India Steam Navigation Company, which is again more than 200,000 tons behind the North German Lloyd. After this the intervals are smaller. In each case the average tonnage is given, as well as the tonnage of the smallest and of the largest vessels of the fleet.

The second and third tables are devoted to companies operating more than 100,000, but less than 200,000, gross tons of steamers. Twenty-one of these are British, in the second table, while the third table includes those of other countries. The fourth and fifth tables give, respectively, the British, and the other, companies with more than 80,000 tons gross. The sixth table gives the six lines included, as mentioned above, because of certain noteworthy characteristics.

The seventh table shows a recapitulation of the first six, giving the number of lines under each several flag; the number of ships; the total gross tonnage and the average gross tonnage. The second part of this table shows the number of large ships (10,000 tons and upwards) under each flag, with the total gross tonnage and the average tonnage of these large ships.

The eighth table is a development of this latter feature, and shows by companies the ships of over 10,000 tons gross, with total and average gross tonnage; percentage of total tonnage represented by these large ships; and the number of ships included, of over 15,000, and of over 20,000 tons gross, respectively. The White Star Line is shown here to have pre-eminence, with twenty vessels and 290,791 gross tons. The largest average is accredited to the Great Northern Steamship Company, the figure being 20,718 tons. This, however, is scarcely a fair rating, because of the fact that there is only one ship. Aside from this, the Cunard Steamship Company has the largest average, with 17,348 tons per vessel in eleven ships.

With regard to the general tables; we find that four companies have average tonnages exceeding 10,000, these being the White Star Line with 12,038, the Cunard with 10,193; the Holland-America Line with 12,044; and the Great Northern Steamship Company with 20,718. In nearly all cases the average is brought low, because of the inclusion of the figures for tenders. These are of more than 100 tons, but naturally operate very markedly to reduce the average for the entire number of ships. One conspicuous case where this does not so operate is that of Burrell & Son, in the fourth table. We find here twenty-two ships with an average of 4,376 tons gross, while the smallest ship is of 4,317 tons, and the largest of 4,432. There are other cases where the smallest ship is even larger than in this case (the Holland-America

TABLE I.—OVER 200,000 GROSS TONS.

	No.	Tons.	Average.	Small.	Large.
(*b*) Hamburg-American Steamship Co.	175	847,374	4,842	229	24,581
(*b*) North German Lloyd Steamship Co.	144	641,329	4,454	112	19,361
(*a*) British-India Steam Navigation Co.	111	440,391	3,967	192	7,703
(*a*) P. & O. Steam Navigation Co.	61	380,046	6,230	108	10,512
(*a*) White Star Line	29	349,091	12,038	395	24,541
(*a*) Elder, Dempster & Co	108	308,979	2,861	107	7,585
(*c*) Messageries Maritimes	69	300,657	4,357	670	6,879
(*a*) Currie, Donald & Co	47	265,222	5,643	158	12,975
(*g*) Consolidated Steamship Lines Co.	105	262,701	2,502	122	6,500
(*d*) Nippon Yusen Kaisha	90	261,300	2,903	109	7,463
(*e*) Navigazione Générale Italiana	101	253,518	2,510	165	9,203
(*a*) Ellerman Lines	61	249,759	4,094	739	9,700
(*a*) Cunard Steamship Co	24	244,640	10,193	287	31,938
(*b*) Hansa Steamship Co	53	234,696	4,428	158	7,217
(*c*) Compagnie Générale Transatlantique	61	218,660	3,585	278	13,753
(*a*) Ocean Steamship Co	38	212,618	5,595	405	9,017
(*a*) Leyland Line	37	209,587	5,665	2,800	10,418

(*a*), British; (*b*), German; (*c*), French; (*d*), Japanese; (*e*), Italian; (*g*), American.

TABLE II.—OVER 100,000 GROSS TONS.

British.	No.	Tons.	Average.	Small.	Large.
T. & J. Harrison	39	195,514	5,013	618	9,599
Pacific Steam Navigation Co.	45	183,541	4,079	214	9,266
Clan Line	45	183,324	4,074	2,600	5,856
Thos. Wilson, Sons & Co.	83	181,384	2,185	155	6,035
Canadian Pacific Railway Co.	35	180,094	5,146	366	14,191
Royal Mail Steam Packet Co.	43	179,328	4,170	180	11,073
Furness, Withy & Co.	59	173,238	2,936	892	5,520
Allan Line	30	170,226	5,674	233	11,436
Wm. Thomson & Co. Lines	46	147,387	3,204	1,010	4,369
R. Ropner & Co	44	136,390	3,100	1,782	4,621
Union Steamship Co. of New Zealand	63	132,812	2,108	112	6,500
Maclay & Macintyre	42	130,858	3,116	1,509	4,846
China Navigation Co.	66	126,501	1,917	269	3,397
Lamport & Holt Line	29	125,600	4,331	1,671	8,406
Anchor Line	24	122,907	5,121	3,069	9,250
Anglo American Oil Co.	26	111,748	4,298	339	9,196
Bucknall Bros.	26	107,960	4,152	621	5,585
Prince Line	42	105,653	2,516	1,888	6,409
New Zealand Shipping Co.	16	104,383	6,524	3,393	8,349
Watts, Watts & Co.	30	103,744	3,458	1,940	4 881
Hain Steamship Co.	34	100,762	2,964	2,098	3,896

TABLE III.—OVER 100,000 GROSS TONS.

Foreign.	No.	Tons.	Average.	Small.	Large.
Lloyd Austria Co. (Austrian)	65	194,485	2,992	186	7,588
(*b*) Hamburg-So. American S. S. Co.	41	182,755	4,457	125	9,700
(*b*) Kosmos Steamship Co.	35	167,329	4,781	3,047	6,982
(*g*) International Mercantile Marine*	18	164,147	9,119	163	12,760
Danish-American Line (Danish)	119	152,557	1,282	110	10,095
(*b*) German-Australian Steamship Co.	31	137,289	4,429	4,187	5,155
Chargeurs Reunis (French)	33	135,260	4,099	498	5,594
(*i*) Compagnie Russe de Navigatione	80	119,935	1,499	156	5,090
(*i*) Flotte Volontaire Russe	22	109,026	4,956	1,523	10,982
Holland-America Line (Dutch)	9	108,428	12,044	6,280	24,200
Osaka Shosen Kaisha (Japanese)	103	107,065	1,039	101	3,376

(*b*), German; (*g*), American; (*i*), Russian. * Includes several vessels of the Red Star Line operating under the British and Belgian flags.

TABLE IV.—OVER 80,000 GROSS TONS.

British.	No.	Tons.	Average.	Small.	Large.
China Mutual Steam Navigation Co.	17	96,693	5,688	3,883	9,021
Burrell & Son	22	96,275	4,376	4,317	4,432
Indo-China Steam Navigation Co.	40	95,660	2,392	1,065	4,895
Booth Steamship Co.	34	94,845	2,790	875	6,439
James Westoll	37	93,097	2,516	949	3,920
R. P. Houston & Co.	25	92,662	3,706	2,279	5,756
T. E. Radcliffe & Co.	26	91,151	3,506	1,823	5,084
Atlantic Transport Co.	13	90,448	6,956	2,847	13,403
Runciman, Walter & Co.	26	89,056	3,425	2,733	4,119
A. Weir & Co.	21	81,537	3,883	425	6,235

TABLE V.—OVER 80,000 GROSS TONS.

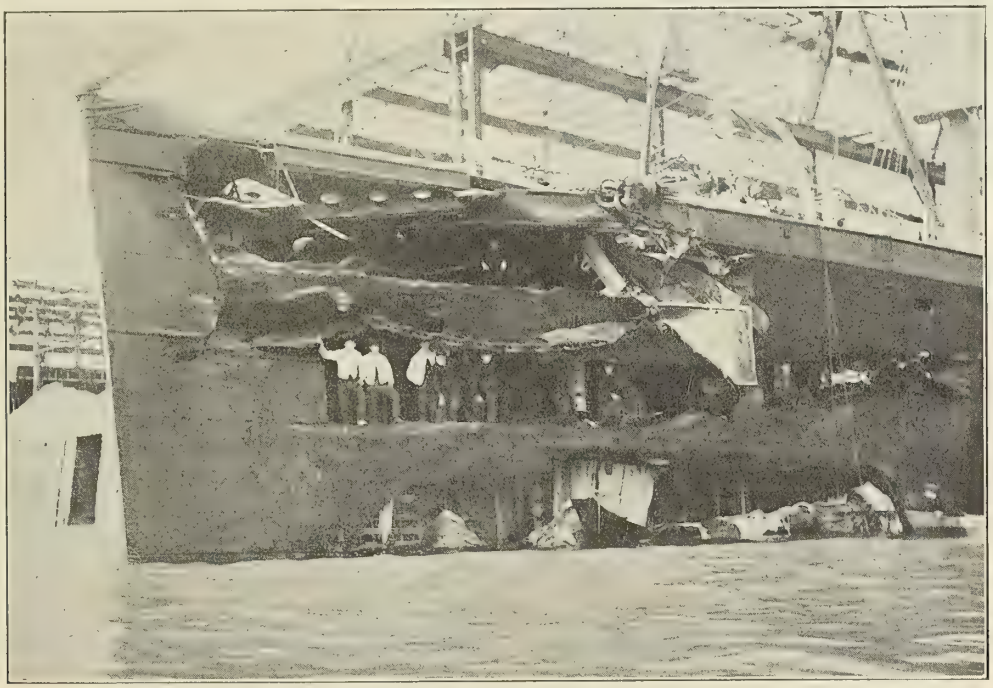
Foreign.	No.	Tons.	Average.	Small.	Large.
(*b*) Woermann Line	40	99,371	2,484	171	6,225
(*k*) Nederland Steamship Co.	23	99,330	4,319	832	6,500
W. Wilhelmsen & Co. (Norwegian)	31	93,929	3,030	1,605	4,375
(*g*) American-Hawaiian Steamship Co.	13	90,252	6,942	4,408	8,671
(*f*) Unione Austriaca di Navigazione	25	89,505	3,580	679	6,125
(*g*) Pacific Mail Steamship Co.	18	88,390	4,911	203	13,638
(*b*) German East Africa Line	23	87,036	3,784	226	6,387
(*g*) Southern Pacific Company	21	85,584	4,075	152	6,878
Compañia Trasatlantica (Spanish)	23	85,396	3,713	466	6,748
(*c*) Société Générale de Transports	26	80,620	3,101	290	5,550

(*b*), German; (*c*), French; (*f*), Austrian; (*g*), American; (*k*), Dutch.

Line has nothing under 6,280 tons), but nowhere else is there such a very marked uniformity in the size of the ships.

By excluding all vessels of under 1,000 tons gross, the White Star average tonnage becomes 12,225; and the Cunard, 11,079; while the Holland-America figure remains at 12,044, and the Great Northern at 20,718. This exclusion raises the average tonnage of Dutch ships in the tables to 6,675, retaining first position in this regard.

The Consolidated Steamship Lines Company, which is credited with the ninth position in the list of large lines, is a recent consolidation of several coastwise lines on the east coast of the United States, and is said to be in fiscal difficulties.



THE HOLE OPENED UP IN THE PORT BOW OF THE OTTAWA, IN COLLISION WITH THE TROLD.

TABLE VI.—OTHER NOTABLE LINES.

	No.	Tons.	Average.	Small.	Large.
(*g*) Great Northern Steamship Co.	1	20,718	20,718	20,718	20,718
Aberdeen Line (British)	7	42,468	6,067	3,726	11,400
Lloyd Brazileiro (Brazilian)	34	51,885	1,526	240	3,840
(*l*) China Merchants Steam Navigation Co.	30	55,347	1,845	505	3,373
Axel Broström & Son (Swedish)	26	49,406	1,900	331	4,134
Idaria Massousieh (Turkish)	40	44,685	1,117	114	4,580

(*g*), American; (*l*), Chinese.

TABLE VII.

	Lines.	Ships.	Tons.	Average.	Large Ships.	Average.	Largest.
Britain	41	1,651	6,627,579	4,014	46—676,021	14,696	31,938
Germany	8	542	2,397,179	4,821	29—405,486	13,982	24,531
France	4	189	735,197	3,890	3— 36,067	12,022	13,753
America	6	176	711,792	4,044	15—187,833	12,522	20,718
Japan	2	193	368,365	1,908	.....	.....	7,463
Austria	2	90	283,990	3,155	.....	.....	7,588
Italy	1	101	253,518	2,510	.....	.....	9,203
Russia	2	102	228,961	2,245	1— 10,982	10,982	10,982
Holland	2	32	207,758	6,492	6— 89,268	14,878	24,200
Denmark	1	119	152,557	1,282	2— 20,180	10,090	10,095

TABLE VIII.—SHIPS OVER 10,000 TONS GROSS.

	No.	Tons.	Average.	*m*	*n*	*r*
(*a*) White Star Line	20	290,791	14,540	83.3	2	4
(*b*) Hamburg-American Line	14	210,384	15,027	24.8	3	2
(*b*) North German Lloyd Co	15	195,102	13,007	30.4	3	..
(*a*) Cunard Steamship Co	11	190,832	17,348	78.	2	2
(*g*) American Line (including Red Star)	10	117,541	11,754	71.6	..	..
Holland-America Line (Dutch)	6	89,268	14,878	82.3	1	1
(*a*) Currie, Donald & Co	5	61,127	12,225	23.	..	..
(*a*) Pacific Mail Steamship Co	4	49,574	12,394	56.1	..	..
(*c*) Compagnie Générale Transatlantique	3	36,067	12,022	16.5	..	..
(*a*) Royal Mail Steam Packet Co	3	31,647	10,549	17.6	..	..
(*a*) Canadian Pacific Railway Co	2	28,380	14,190	15.8	..	..
(*a*) Peninsular & Oriental Co	2	21,021	10,511	5.5	..	..
(*a*) Leyland Line	2	20,823	10,412	9.9	..	..
(*g*) Great Northern Steamship Co	1	20,718	20,718	100.0	..	1
Danish-American Line (Danish)	2	20,180	10,090	13.2	..	..
(*a*) Aberdeen Line	1	11,400	11,400	26.9	..	..
Russian Volunteer Fleet (Russian)	1	10,982	10,982	10.1	..	..

(*a*), British; (*b*), German; (*c*), French; (*g*), American. *m*, percentage of total tonnage in ships of over 10,000 tons gross; *n*, number of ships between 15,000 and 20,000 tons; *r*, number over 20,000 tons gross.

Collision Between the Ottawa and the Trold.

The fog-bound waters of the entrance to the St. Lawrence have witnessed another serious collision, that between the Dominion Liner *Ottawa* and the collier *Trold*, which occurred May 11. Both vessels were severely injured, and the *Ottawa*, which was on its way from Quebec, was obliged to put back, while the collier made its way to Gaspe Basin, the nearest port. Our photograph of the bow of the *Ottawa* shows the serious extent of the damage, the cut being so extensive as to flood the forepeak and hold No. 1. This gave her a decided trim by the head, resulting in a draft forward of at least 30 feet, and reduced her speed to below 7 knots.

The *Trold* was bound for Quebec from Sydney, Australia, with a heavy cargo of coal, and she also was partially flooded, and down by the head.

The *Ottawa*, which was built in 1874 by Harland & Wolff, of Belfast, was formerly the *Germanic*, used in the New York service. She is an iron screw steamer with eight watertight bulkheads and provision for water ballast. She measures 455 feet in length, 45 feet 2 inches beam, and 34 feet depth. Her gross and net tonnages are respectively 5,071 and 2,999. She has one triple expansion engine with cylinders 35½, 58½ and 96 inches in diameter, and a stroke of 69 inches.

The *Trold* is a steel screw steamer, flying the Norwegian flag, and built in 1898 by J. Priestman & Company, Sunderland. She has five watertight bulkheads and is fitted with web frames. She is schooner-rigged, and fitted with poop, bridge and forecastle. The length is 325 feet, beam 47 feet, and depth 25 feet 6 inches. The net and gross tonnages are respectively 2,075 and 3,247. She is propelled by one triple-expansion engine with cylinders 25, 41 and 67 inches in diameter and a stroke of 45 inches.

The *Trold* reached New York early in June, and was repaired at the Erie Basin, in South Brooklyn.

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Changes to be made in copy, or in orders for advertising, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 10th of the month.

Lake Passenger Steamers.

The Great Lakes of North America and the numerous small lakes and navigable rivers along and near the Atlantic coast have given rise, as a means of rapid and ready communication, to a fleet of magnificent steamboats, many of which can be said to be without an equal anywhere in the world. The lake type of steamer for freight purposes is well known, being a highly specialized unit of great carrying power and particular utility for the purpose for which it is intended. The passenger steamers on the lakes, however, are not by any means this same type of vessel. They are built for runs varying in general from 150 to nearly 2,000 miles, and, in the latter case, resemble transatlantic liners, though of considerably smaller size.

It is with the vessels intended for the shorter runs, however, that we are here concerned. These steamers are propelled, some of them by paddle wheels, some by propellers, and, in one or two isolated cases, the propellers are actuated by steam turbines. The typical American lake, sound and river steamer, however, is one in which paddle wheels are relied upon for propulsion, because of the fact that in many cases the waters to be traversed are shallow, and, the cargo carried being relatively small, there is not much difference in immersion of the paddle-wheel blades between full load and light load conditions.

Among the most prominent of the steamers of this type is the *City of Cleveland,* built by the Detroit Shipbuilding Company early in 1907, only to be destroyed by fire, as briefly mentioned in our issue of July, 1907. The vessel was promptly rebuilt, and our description of her this month shows a magnificent example of the lake steamer, providing accommodation for some hundreds of passengers during the night trip, and a much larger number during the day trip. This vessel makes the run between Detroit and Cleveland, on Lake Erie, a distance of approximately 110 miles, twice a day, and is capable of a maximum speed, which is called for during the day trip, of nearly 22 miles per hour (19 knots).

In May of 1906 we described at some length the Hudson river steamer *Hendrick Hudson,* which is from the boards of the same designer, and which has made a splendid record on the river during her first two seasons of operation. This vessel is intended entirely for day service, and has accommodations for carrying 5,000 passengers. The contract called for a speed of 20 knots, which has been easily exceeded in the daily runs. In this case, as with the *City of Cleveland,* the propelling engine is of novel type, being a three-cylinder compound, working directly on the paddle-wheel shaft without the intervention of the usual walking beam. The cylinders are inclined to the horizontal, and are placed low down in the hold, thus aiding stability, and tending to counteract the fact that broad decks for the accommodation of passengers reach high up into the air above the shallow and relatively narrow hull.

A steamer somewhat similar in type is the *Commonwealth,* of the Fall River Line, operating through Long Island sound between New York and Fall River. This is considerably larger than either of the others mentioned, having a gross tonnage of 5,980, as compared with 4,568 for the *City of Cleveland* and 2,847 for the *Hendrick Hudson.* She has a length over all of 456 feet, a width of hull of 55 feet and a depth of 22 feet. As illustrating the immense breadth of the decks, it may be stated that her width over the paddle-wheel guards is no less than 96 feet, this indicating an overhang of more than 20 feet on each side. The *Commonwealth* has engines developing a total of 11,000 horsepower, which is 2,500 more than the next most powerful among the paddle steamers of this type (the *Priscilla,* of the same line), and is about double that

of the *Hendrick Hudson,* and nearly double that of the *City of Cleveland.*

Scout Cruiser Trials.

In another column will be found a brief description of the official trial trips of three scout cruisers recently commissioned for service in the United States navy. These vessels are all provided with hulls identical in dimensions and form, and are driven by three different types of propulsion; one having twin screws with reciprocating engines; another, twin screws with Curtis turbines; while the third has four screws and Parsons turbines. In each case the designed horsepower was 16,000, which figure was considerably exceeded by the two turbine-propelled ships.

The chief interest in these ships lies in the splendid opportunity for comparing results of propulsion by these three different agencies. Not only have we the comparison afforded by the results of the trial trips, but it is proposed to run the ships through a series of trials side by side, thus insuring identical weather and other conditions, with a view to determining beyond the peradventure of a doubt, at least so far as the present installations are concerned, the relative efficiencies of the three propulsive agencies, both as regards possibilities for extreme economy of obtaining the power, and as regards speed and for overload, this latter feature limiting the steaming or scouting radius.

It is not at all improbable that the information derived from these series of tests will be made use of, in connection with possible changes in the propellers, in the designing of the next large warships placed under construction for the United States navy. Several sets of propellers have been tried on some of these scouts, but it is quite unlikely that the ultimate maximum of efficiency has yet been attained on any of them, and the trials ought to demonstrate in just what particulars better results might be looked for.

Fire Boats.

In this issue we are describing a number of small vessels fitted with fire-fighting appliances and intended for use in connection with fires along the water fronts of some of the largest cities in the world. It is now some years since the *New Yorker,* long the most powerful vessel of this type in existence, and even now, so far as we are aware, exceeded in power by only two boats of her sister fleet, was put into service in the harbor of New York. At the time of her inception, the idea was by no means novel; for we understand that vessels of this general character have been in use on the Thames for a full half century. In spite, however, of this lack of novelty, the *New Yorker* presented so many interesting features, by virtue of her great power and general efficiency, that she has been repeatedly referred to as the leading exponent of this particular means of fighting fires.

The conditions attending the design of such a vessel are more or less peculiar. In the first place, there must be provided propulsive power for a rapid approach to the scene of action; after this, the propulsive machinery is needed scarcely at all, for the warping of the vessel into more advantageous positions for fighting the fire can usually be done by means of lines. At this time, however, a large amount of power is required for the operation of the pumps, and, in the Chicago fire boat, described this month, a novel arrangement has been entered into by which the same prime movers are used for both purposes. These are steam turbines direct connected to both centrifugal pumps and electric generators. As a general proposition, while the generators are under service, furnishing power to the motors on the propeller shafts, no power is required for the pumps, and the impellers run idle, with very little loss by friction. On the other hand, while the boat is fighting a fire, and the pumps are in full service, the propellers are normally at rest, and, as their motors are not drawing current from the generators, the latter run idle, again with very little friction. So we have a set of machinery thoroughly well adapted to the particular purpose, and which may on emergency be used momentarily for both propelling and pumping at the same time. The flexibility of such a system is very great, because of the ease of control from the pilot house of the main propulsive elements, without the necessity of transmitting orders through the engine room.

Continental Passenger Traffic.

Once more the oft-repeated rumor is afoot to the effect that the Cunard Steamship Company is about to seek an opening in the channel, in order to compete with other lines in the continental passenger traffic, which is said to be the "cream" of the whole Atlantic business. The new report, which is officially denied, is to the effect that, without abandoning Liverpool as a terminus, Queenstown is to be dropped and stops at Plymouth and Cherbourg substituted. The Plymouth stop would expedite the carriage of the mails between New York and London, while that at Cherbourg would tap the continent and provide ready access to Paris and the tourist resorts of the north of Europe.

If such a change is made, the eastern end of the Cunard route doubles back on itself, Cherbourg being about 180 nautical miles to the east of the Scilly Islands, where the turn up to Liverpool would be made. This would involve so much in the way of delay for the fast steamers making it as to amount to a positive nuisance. The ideal method of attacking the problem would seem to be that adopted by the White Star Line, which, without abandoning Liverpool, has a service to channel ports as well, this latter service being distinct from that to Liverpool, and no steamer making both "termini," so to speak, on any one trip. This involves a larger fleet of vessels than would be required for the single service, but the Cunard Company has such a fleet already in being, and could readily institute such a change.

Progress of Naval Vessels.

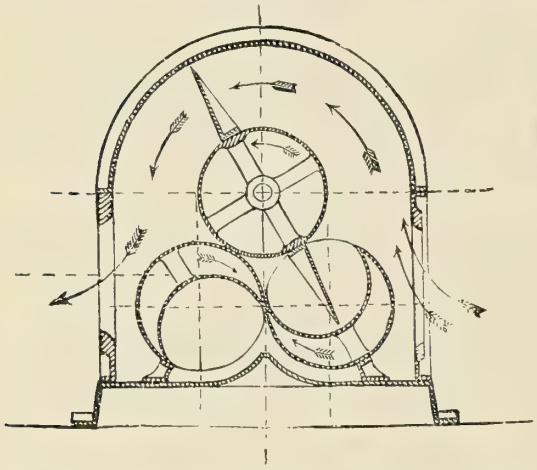
The Bureau of Construction and Repair, Navy Department, reports the following percentages of completion of vessels for the United States Navy:

	Tons.	Knots.		July 1.	Aug. 1.
BATTLESHIPS.					
South Carolina..	16,000	18½	Wm. Cramp & Sons.....	51.9	55.
Michigan.....	16,000	18½	New York Shipbuilding Co.....	57.2	60.4
Delaware.....	20,000	21	Newport News S. B. & D. D. Co.	31.6	35.3
North Dakota...	20,000	21	Fore River Shipbuilding Co.....	40.5	45.7
ARMORED CRUISER.					
Montana.....	14,500	22	Newport News Co.....	99.2	100.
SCOUT CRUISER.					
Salem.....	3,750	24	Fore River Shipbuilding Co.....	98.9	100.
TORPEDO BOAT DESTROYERS.					
Number 17.....	700	28	Wm. Cramp & Sons.....	31.1	38.7
Number 18.....	700	28	Wm. Cramp & Sons.....	26.9	35.7
Number 19.....	700	28	New York Shipbuilding Co.....	33.8	42.2
Number 20.....	700	28	Bath Iron Works.....	13.	14.
Number 21.....	700	28	Bath Iron Works.....	13.	14.
SUBMARINE TORPEDO BOATS.					
Number 13.....	—	—	Fore River Shipbuilding Co.....	49.3	51.9
Number 14.....	—	—	Fore River Shipbuilding Co.....	49.4	51.9
Number 15.....	—	—	Fore River Shipbuilding Co.....	48.6	50.9
Number 16.....	—	—	Fore River Shipbuilding Co.....	48.8	51.1
Number 17.....	—	—	Fore River Shipbuilding Co.....	35.8	42.4
Number 18.....	—	—	Fore River Shipbuilding Co.....	32.6	41.8
Number 19.....	—	—	Fore River Shipbuilding Co.....	31.7	41.3

ENGINEERING SPECIALTIES.

A Rotary Pressure Blower.

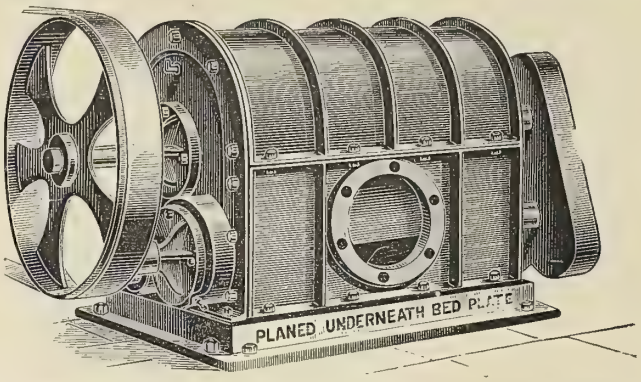
A device placed on the market by the Baker Blower Engineering Company, Stanley street, Sheffield, is designed for the moving of heated air and gases, and is supplied with outlet delivery on either side, as viewed from the driving pulley.



These blowers are said to be simple and not liable to get out of order, having no sliding vanes or pistons working under pressure internally, and, therefore, subject to wear and tear. A great volume of air is passed at a low speed. All the working parts requiring attention and lubrication are external. The internal arrangements can be seen by removing the top cover, without disturbing either inlet or outlet connection.

The internal parts do not move in absolute contact, but are so close as to be practically tight. This results in confining the wear to the journals and gear, where ample surfaces are provided, all adjustable from the outside. The shafts are large in diameter and have adjustable stuffing boxes, while the revolving drums are carefully balanced.

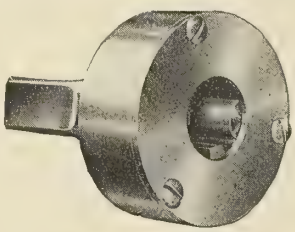
The blowers are listed in regular sizes rated from 3,000 to 780,000 cubic feet of air per hour against a head of 6 inches of water. The requirements vary from ½ to 23 horsepower at respectively 300 and 130 revolutions per minute. The approximate over-all dimensions for the smaller size are 18



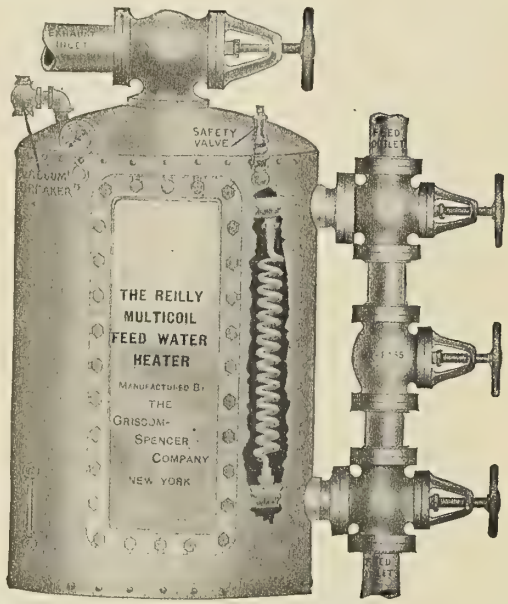
by 6¾ inches by 10 inches high; for the larger size, 127 by 84 inches by 96½ inches high. The weights increase successively from 1¼ to 220 cwt.

A Reversible Stay-bolt Chuck.

It frequently happens when running in a stay-bolt that the bolt will stick and stop and must be backed out part way in order to get a fresh start. The reversible stay-bolt chuck manufactured by the Cleveland Pneumatic Tool Company, Cleveland, Ohio, is designed to be operated in either direction at will. The necessary grip on the bolt is obtained by a loose roller, which changes its fulcrum automatically, and wedges the bolt fast against the two stationary dogs. When the motor to which the chuck is attached is reversed, the roller of the chuck releases its hold and moves to the opposite side, when it again grips the bolt fast. This chuck is designed to drive stay-bolts from ¾ to 1⅛ inches in diameter. It can be applied directly to standard bolts, without the necessity of squaring the ends.



CLEVELAND REVERSIBLE STAY-BOLT CHUCK.



The Reilly Multicoil Feed Water Heater.

The matter of feed-water heating on shipboard is a most important detail, for as much as 28 percent of the total work of making steam is generally devoted to raising the temperature of the water up to the boiling point. If the water could be fed to the boilers at the temperature at which steam is made, the steaming capacity of the boiler could be increased by just about this percentage. If also a part of this work of heating the water can be done by the use of exhaust steam that would otherwise be wasted and merely thrown into the condenser, requiring more work to condense it, besides losing all of the valuable heat stored up in it, the feed-water heater is justified.

The Griscom-Spencer Company, New York, manufactures the Reilly multicoil feed-water heater, which has recently undergone decided improvement in economy and weight. The union joint connection between each copper heating coil and the top and bottom headers of the heater has been improved in one or two details, and the door construction has been changed from the old method of bolting the cast-iron door frame to the shell to a more modern method of flanging out the shell itself into a kind of nozzle, and riveting to this nozzle a welded angle iron collar, which makes a seat for a light door of pressed steel plate. This construction is very light, and is a most neat and workmanlike job.

The builders have gone deeply into the subject of the economy of feed-water heating and its relation to modern power plants, both scientifically and practically. From the data that they have compiled in their experiments and in their marine experience, they assert that a Reilly multicoil heater will pay for itself under general conditions in about forty-one working days, and after that all the saving in fuel, as well as the saving in boiler repairs due to feeding hot water instead of cool water to the boilers, is net profit.

TECHNICAL PUBLICATIONS.

Definitions in Navigation and Nautical Astronomy. By P. Groves-Showell. Size, 5¼ by 7¼ inches. Pages, 107. Figures, 96. Philadelphia, 1908: J. B. Lippincott Company. Price, $1.25; and London, Charles Griffin & Company, Ltd. Price, 2/6 net.

This work gives special consideration to students desiring to present themselves for examinations for a marine officer's certificate. It is divided into three parts, dealing respectively with definitions, instruments and miscellaneous items, and is followed by an index. Under definitions are taken up spheres and angles, general considerations of navigation, including departure; great circle sailing; deviation of the compass; leeway, etc. Under nautical astronomy are definitions of such terms as altitude, zenith distance, azimuth, equinoctial, ecliptic and right ascension. Time is next given consideration, while charts are given showing lines of magnetic variation and magnetic dip.

Under the head of instruments are shown the mariner's compass, chronometer, sextant, the use of the vernier, sounding machine, patent log, barometer and thermometer. The miscellaneous section gives tables of weights and measures, and rules for finding areas and volumes of figures of various shapes.

Beeson's Marine Directory of the Northwestern Lakes. Size, 6¾ by 9½ inches. Pages, 272. Illustrations, 66. Chicago, 1908: Harvey C. Beeson. Price, $5.00 (£1).

This is the twenty-second year of publication of a directory of all the steam and sailing vessels on the Great Lakes, including both American and Canadian craft. Under separate headings are the iron ore carriers, lumber vessels and particulars of boilers and machinery of the steam vessels on the lakes. Statistics are given showing the traffic through the Sault Sainte Marie canals, and notes covering the various steamboat and transportation lines on the lakes. The illustrations are mostly half-tones, representing subjects peculiar not only to the lakes but also to the ocean, including passenger and freight steamers, steam and sailing vessels, lake, ocean, coastwise and river craft, motor boats, yachts, machinery and a number of vessels, interesting principally from the point of view of their antiquity or oddity of design.

The main new feature this year is a descriptive list of all the American ports on the Great Lakes, with details of population, commerce and other items of interest.

Hydraulics. Vol. II. The Resistance and Propulsion of Ships. By S. Dunkerley, D. Sc. Size, 5½ by 8½ inches. Pages, 253. Figures, 115. London and New York, 1908: Longmans, Green & Company. Price, 10/6 net and $3.00.

The first volume dealt with hydraulic machinery. This second one is divided into six chapters, followed by a complete index. These chapters deal respectively with stream lines, waves, the eddy, skin and wave-making resistance of ships, wave-making resistance, trials on full-sized ships, and theoretical considerations affecting the propulsion of ships. The first chapter takes up the subject from a theoretical point of view, with the aid of the calculus. It is followed by a chapter dealing with waves in both deep and shallow water, and including waves of translation, oscillating and capillary waves, etc. The trochoidal wave system is given considerable space, and the subject of the velocity of propagation is dealt with at some length. The resistance, due to eddies and waves, forms the subject of a chapter in which Froude's classic experiments are given prominent place.

In the fifth chapter the laws of comparison are taken up, showing the relation between sizes and corresponding speeds and the method of passing from one size to another, or one speed to another, in calculations. Under theoretical considerations appears a discussion of types of propellers, including the jet propeller, paddle wheel and screw propeller. The first two are given the usual brief attention, while the third naturally occupies the bulk of the chapter. Among other things discussed are the effect of the thickness of blade and methods of testing model propellers, either with or without an attendant hull. The Admiralty method of designing screw propellers is outlined, while the end of the chapter is concerned with a discussion of such abnormal phenomena as cavitation and the rapid rotation of propellers in heated water.

The Slide Rule—A Practical Manual. By Charles N. Pickworth. Pages, 113 + xvi. Figures 30. Size, 5 by 7 inches. New York, 1908: D. Van Nostrand Company. Price, $1.00 net. London: Whittaker & Co., and Manchester, Emmott & Co., Ltd. Price, 2/6.

This is the eleventh edition of a work dealing with the use of a calculating rule, and takes up in considerable detail the methods of procedure in making computations by this means. Nearly all of the volume is devoted to the usual type of slide rule, being that in the form of a ruler 10 inches long. Special types of rules, however, are given at the end of the volume: the Fuller spiral rule, the Thacher cage-type calculating instrument and a number of circular calculators of the size and form of a watch being here described. Numerous examples are given, with explanations in detail of the method of obtaining results.

Board of Trade Arithmetic for First-Class Engineers. By Peter Youngsen. Pages, 108. Figures, 19. Size, 4¾ by 7 inches. Glasgow, 1908: James Munro & Co. Price, 3/– net and $1.00.

The work consists of a series of sixteen papers of questions asked at Board of Trade examinations for engineering licenses. Each paper consists of a considerable number of questions, and is followed in the second portion of the work by answers to these questions. The questions cover computations and explanations of various boiler calculations, size of coal bunkers, coal consumption, propeller data, engine horsepower and elementary navigation, besides a large number of questions of a general arithmetical nature, and dealing largely with marine engineering subjects.

In the preface it is pointed out that the carrying out of results to a large number of decimal places is not usually called for, and stress is laid upon the importance of carefulness in the steps leading up to the result rather than too much refinement in the result itself.

Signal Manual for the Use of the Mercantile Marine. By Capt. W. G. Rugg. Pages, 28. Figures, 9 (four in colors),

Size, 4½ by 6 inches. Glasgow, 1908: James Munro & Co. Price, 1/– net and 30 cents.

This little pocket manual is the second edition of a work giving instructions in the making of signals with flags by means of spelling them out, or of sending messages by codes. The use of the semaphore fixed to a mast or in the shape of a man with flags is taken up, this being based largely on the Morse code. A number of special signs and methods of flashing signals by lights are also mentioned. The international code of alphabetical and special one-flag, two, three and four-flag signals is illustrated in colors (white, black, red, blue and yellow).

Consular Requirements for Exporters and Shippers. By James Shaw Nowery. Size, 5 by 7½ inches. Pages, 84. Glasgow, 1908: James Munro & Co. Price, 2/6 net; 75 cents.

This little book includes copies of all forms of consular invoices, with some useful hints as to drawing out bills of lading and other documents necessary in the shipping trade. As every shipper knows, or should know, attention to details is very essential, especially with regard to consular requirements imposed by various foreign countries, which often involves the perusal of lengthy documents. The author of this little book admirably sets out the gist of these in a concise and methodical form, which makes it an almost indispensable work to anyone engaged in export trade.

QUERIES AND ANSWERS.

Questions concerning marine engineering will be answered by the Editor in this column. Each communication must bear the name and address of the writer.

Q. 410.—It has frequently been asserted that United States battleships make their trial speeds on a very light displacement. Is this lighter in proportion than is the case in other navies? J. P.

A.—Each navy has a separate method of setting its requirements in this connection, but the general results are not very discordant. Figures which have been put into our possession, but which we cannot guarantee, show weights of the various items making up the displacement at normal load of the *Nebraska, Connecticut* and *Michigan* of the United States navy, and the *Dreadnought* of the British navy. The full-load displacements for the three American ships are also given, with an estimate for the *Dreadnought,* which will be discussed later:

	Connecticut		*Michigan*	
	Normal.	Full Load.	Normal.	Full Load.
Hull and fittings*..	7,434	7,434	7,469	7,469
Armor	3,992	3,992	4,047	4,047
Battery and am'tion.	1,339	1,536	1,118	1,300(a)
Machinery	1,500	1,500	1,577	1,577
Feed water.....	66	100	66	100
Coal	900	2,275	900	2,200
Equip't and stores†.	769	829	823	924(a)
	16,000	17,666	16,000	17,617

	Nebraska		*Dreadnought*	
	Normal.	Full Load.	Normal.	Full Load.
Hull and fittings*..	6,655	6,655	6,955	6,955
Armor	3,771	3,771	4,100	4,100
Battery and am'tion.	1,213	1,417	2,930	2,930(b)
Mach'ry and water.	1,830	1,830	2,190	2,190(b)
Coal	900	1,775	900	2,700
Equip't and stores†.	579	646	825	825(b)
	14,948	16,094	17,900	19,700

The items marked (a) have been closely estimated. The items marked (b) have been here assumed to undergo no change between normal load and full load of the vessel.

* Includes protective deck.
† Includes officers, crew and effects.

This assumption is probably not correct. We have been informed by an English contemporary that with a complete outfit and full load on board, the *Dreadnought* was recently noticed drawing 31 feet 6 inches, in place of the legendary 26 feet 6 inches. The difference, assuming a coefficient of waterplane area of 0.75, would amount to about 4,200 tons in displacement, and would make the full-load displacement of the *Dreadnought* 22,100 tons. This is probably too high an estimate, and we are unable to verify it. On the other hand, it is a fact that the *Connecticut,* on starting from Hampton Roads for the Pacific, was very heavily laden with an immense amount of stores, etc., and unquestionably displaced more than the 17,666 tons with which she is credited at full load. The fact remains, however, that practice, as between the two navies mentioned, is not very different in actual working out, though it may appear to be on paper.

Some comment may be occasioned by the fact that the *Dreadnought's* battery appears disproportionately heavier than that of the *Michigan,* while the *Dreadnought* carries ten 12-inch guns to the *Michigan's* eight. This is due to the fact that it is British practice to include in such statements of weight of battery and ammunition the weight also of all armor protecting the battery. This includes the weight of turret armor and barbette armor. Under these headings are also included the motors and other auxiliary appliances for operating the turrets, guns and ammunition hoists, which in American practice are included under equipment. The item of armor in the *Dreadnought* includes merely vertical armor for the protection of the hull—the flotation and the stability. In the case of the American vessels this includes all armor of every description (except protective deck) as well as backing, bolts and cellulose.

Q. 414.—I have a motor boat 21 feet long, 5 feet 4 inches beam and weighing about 1,100 pounds. There is a two-cylinder two-cycle engine of 4½ horsepower, driving a 16-inch diameter propeller at 700 revolutions per minute. The area of blade is about 23.4 square inches. What is the proper pitch for a speed of 7½ to 8 miles per hour?

2.—What horsepower would be necessary to drive a 20-inch propeller to get speeds of 8 and 10 miles an hour respectively, with the same data as above?

3.—What is the pitch of a propeller, diameter 15½ inches and running 800 revolutions per minute with a 9-horsepower engine, to give 10 or 12 miles an hour with the above boat? R. J. N.

A.—There are two or three discordant features involved in these questions, but we will answer *seriatim* and discuss later.

On page 138 of Durand's "Motor Boats" is a formula for the pitch of a propeller to accompany a given speed and number of revolutions at an assumed slip. This formula is:

$$P = \frac{1{,}056\,V}{N\,(1-s)}$$

where P is the pitch in inches; V is the speed in miles; N is the number of revolutions per minute; and s is the apparent slip of the propeller. Assuming in this case a slip of 22 percent and a speed of 8 miles per hour, we find the pitch figures out at 15½ inches.

2. On page 125 of the same book is a formula for powering motor boats, as follows:

$$H = \frac{A\,B}{K}$$

where A is a function of the weight of the boat (representing the two-thirds power of the number of thousands of pounds in this weight); B is the cube of the speed in miles per hour, and K is a coefficient used for designing and similar to the "Admiralty coefficient." In the first case mentioned, at 8 miles per hour, this coefficient figures out as 121, a very low result. If we use this same figure for the answer of the second question, we find that the horsepower figures out as 8.8 for a speed of 10 miles per hour.

3. Using the formula last above given, we find that for 12 miles per hour the Admiralty coefficient is 204, which ought

easily to be attained in a boat of this size. The pitch, figured on a basis of 12 miles per hour, and an apparent slip of 25 percent, is found to be 21⅛ inches.

For a boat of this size with apparently speedy lines (the relation between weight, length and beam indicates this) it ought to be possible to reach a coefficient of upwards of 200 at 12 miles per hour, and probably no less than 350 at 8 miles per hour. In the latter case it would appear that the speed might be reached with under 2 horsepower, provided the propeller was properly suited to the engine. As to the different diameters of propellers, this in general would not affect the problem unless we reached so great a diameter as to expend a large part of the power in churning up the water (the pitch ratio in this case being small); or unless the diameter is so small that it is difficult to obtain sufficient blade area to prevent the occurrence of cavitation at high speeds. This would appear not to be reached in the present case, because, assuming two blades, we have a total of 46.8 square inches (apparently developed area), from which we may conclude that the projected area is in the neighborhood of 38 square inches. At 12 miles per hour and 9 horsepower, and a propulsive coefficient assumed at 48 percent, we find that the total thrust is about 135 pounds, which would give us a thrust per square inch of a little more than 3½ pounds. Cavitation does not usually begin at a thrust of less than 11 pounds per square inch.

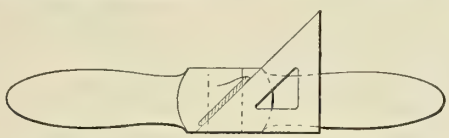
Q. 415.—If water filtered through alum, such as is used for city filtering plants, were fed occasionally to marine boilers, what would be the effect? J. F. W.

A.—If there is only a very small percentage of alum in the water, simply enough to coagulate the minerals in suspension, so that they precipitated promptly, and this is used in conjunction with one or two other chemicals, there would be no possible harm to the metal parts. If there is a strong solution of alum in the water at all times, however, it would not be suitable for a feed water.

The tendency of alum is to combine with scale-forming solids into an exceptionally hard mass. Scale consisting of calcium-sulphate, calcium-carbonate and magnesia becomes as hard as flint, and resists chemical reaction to a great extent. The whole thing hinges, therefore, on the percentage of alum in the water, and how often it is injected. P. B. B.

Q. 416.—What is the simplest method of obtaining the pitch of a propeller? R. A. W.

A.—A method which is simple and in quite general use consists merely in finding the distance from the center of the bore to that section of the blade which is at an angle of 45 degrees from the axis of the bore. This distance is the radius of a circle whose circumference is equal to the pitch, hence the pitch is easily figured.



The method pursued is to lay the wheel on any flat surface, with the axis perpendicular to this surface, and locate the required section of the blade with a 45-degree triangle. The distance from the axis may then be easily measured. Should the shaft be in the propeller, it may be laid down with the shaft parallel to the table, taking care that the center line of the blade is also parallel to the table, and the same course pursued.

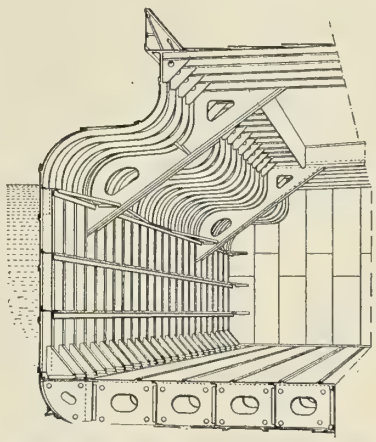
SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Delbert H. Decker, Esq., registered patent attorney, Loan & Trust Building, Washington, D. C.

887,076. TURRET OR SIMILAR VESSEL. CHARLES D. DOXFORD, SUNDERLAND.

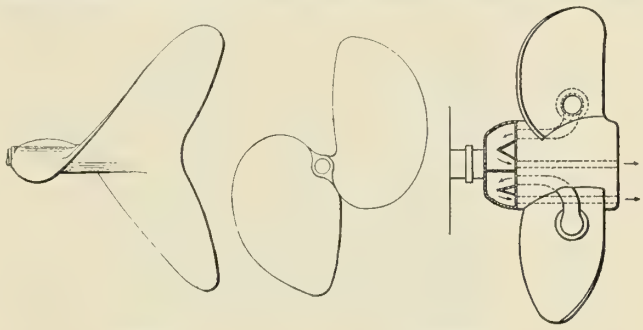
Claim.—In a turret vessel the combination of a hull, a turret forming



the upper part of the vessel and merging into the hull, deckbeams extending across the turret, a double bottom at the bottom of the hull, narrow internal frames extending from the deck beams to the double bottom, leaving an unobstructed space from side to side between the frames, large gusset plates extending from the frames to the deck at intervals in those portions of the vessel where the turret merges into the hull, and small knee plates securing the internal frames to the double bottom. One claim.

887,156. PROPELLER WHEEL. LOUIS J. H. VOSS, MENASHA, WIS.

Abstract.—The invention relates to improvements in propeller wheels, in which there are two similar blades, which commence at the forward end of the hub of the wheel with a small width, and widen out to the desired width, and make a twist along the hub of one-half of a circle, the working sides of the blades, when the boat to which it is applied is going forward, being concaved to a small degree. The objects of the improvement are to produce a wheel that is capable of producing great speed when compared with others of similar diameter and number of revolutions, and one that is adapted for running in shallow water where weeds abound. One claim.



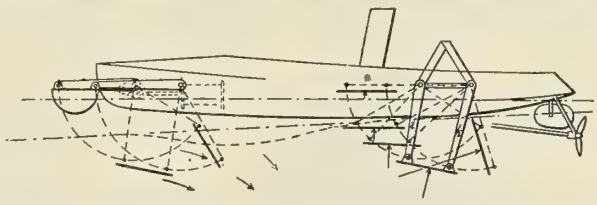
887,156. 887,486.

887,486. PROPELLING DEVICE FOR SHIPS. WILLIAM LOVIS, LONDON, E. C.

Claim 1.—A propelling device for ships comprising a boss or hub having blades, each of which has a perforation, a rotary hollow casing at the front of said propeller, and the chamber of which is divided into compartments, inlet passages connecting said perforations with said compartments, and exhaust passages from said compartments to the rear of said boss or hub. Three claims.

12,791. (REISSUE). MARINE NAVIGATION. SIDNEY A. REEVE, NEW HAVEN, CONN., ASSIGNOR TO WILLIAM M. AND LARNED E. MEACHAM, CHICAGO.

Claim 5.—In a water-conveyance, the combination with a body or vessel for receiving the passengers or load, of inclined supporting plates



connected thereto and moving edgewise through the water at an inclination to the longitudinal horizontal line, to give support to the body or vessel, and a propeller for imparting forward motion to the conveyance, said inclined supporting plates extending below the bottom of the body of the vessel, so that when the conveyance is in motion the body of the vessel may be supported entirely above the surface of the water. Thirteen claims.

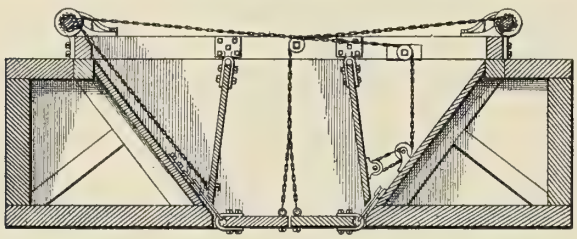
887,873. CABLE TRANSPORTER. JOHN R. TEMPERLEY, JOS. TEMPERLEY AND WILLIAM ALEXANDER, LONDON.

Abstract.—One end of the supporting cable is coiled on the drum of

the winding motor. The cable is passed through a dynamometer and led over a support at the end of the span, but not attached thereto, being left free to run over the support when hauled in or paid out. The cable is then led across the space to be spanned and attached to the support at the other end, or the cable may be carried around a sheave attached to the support and returned across the span and the end attached to a second winding motor, by means of which the cable may be hauled in or paid out, and this motion utilized for moving the carriage to and fro, the cable serving both to support and to convey the load. Twenty-five claims.

887,934. SCOW. JOHN H. GERRISH, BOSTON, MASS.

Claim 2.—A scow having a well, dumping doors controlling the exit therefrom, swinging partitions dividing said well into separate com-

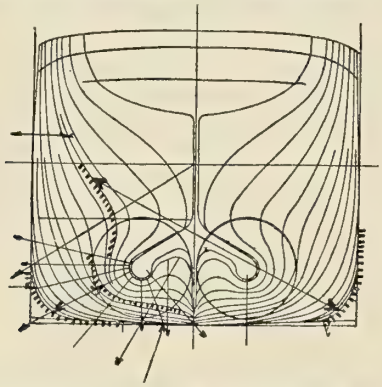


partments, chains for controlling said dumping doors and partitions, shafts located on different sides of said well with which said chains are adapted to make respective connection, and means whereby said shafts may separately be operated. Four claims.

British patents compiled by Edwards & Co., chartered patent agents and engineers, Chancery Lane Station Chambers, London, W. C.

29,623. SHIPS' HULLS. E. COCKBURN, BREMERHAVEN, GERMANY.

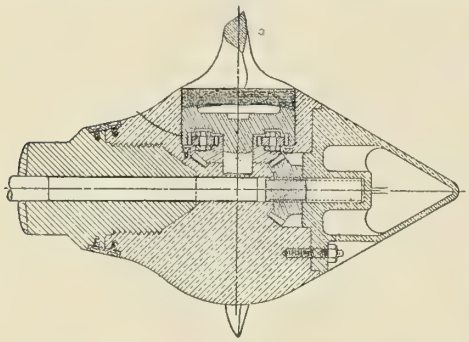
Relates to the form of the afterbody of the twin and triple-screw vessels, and particularly to the bossed frames for the stern tubes. The contour of the sections at about one-eighth of the length of the vessel from the after perpendicular is approximately the same as a



normal bilge at midships. Where the bossed frames run into the normal form of the vessel, the curve is made larger than usual, being, at about one-eleventh of the length of the vessel from aft, about the same as an inverted form of bilge amidships. The lines are preferably faired by diagonals through the center of the shafts. The bottom of the vessel is raised slightly towards the stern.

52. SCREW PROPELLERS. H. J. SPOONER, LONDON.

Relates to feathering propeller blades by means of epicyclic gearing, operated by a shaft within the hollow shaft of steam turbines. A bevel pinion fixed to a shaft engages with bevel wheels, which ride loosely on the tail pieces of blades. The bevel wheels are prevented from moving in the direction of the axis of the blades by means of a framework, which carries change wheels, engaging with the spur pinions cut upon the bosses of the wheels. The blades are screwed into the boss.



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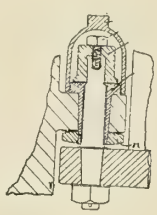


175.

175. RUDDERS. F. T. MURDOCK, GALWALLY, BELFAST.

Rudders are hung from the stern post in such a manner that the pintles are above the gudgeons. The pintles are supported in bushes, secured in place by the nuts, and removable from above the stern braces by screwing the nuts down. A closed nut maintains the pintle in position, and the lower face acts in conjunction with the collar of the bush to form a bearing surface. A lock-nut is fitted to the closed nut. The stern post may be provided with an additional brace, having a pin and nut, which form with the nut an additional bearing surface for the rudder.

326. BINNACLE LAMPS. W. D. WHYTE, GLASGOW.

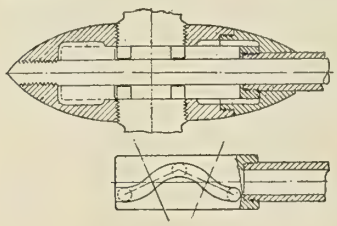
Relates to ships' compasses adapted to be lighted from below. The light, which is directed upwards by a suitable reflector, can be dimmed by rotating the reservoir, in connection with which is provided a combined reflector and obturator. A milled operating head is fitted. The lamp has grooves for attachment to slides at the side of the binnacle. The base is attached by bayonet-like catches, and has a handle.

454. SOUNDING APPARATUS. O. GUTT, BERLIN, GERMANY.

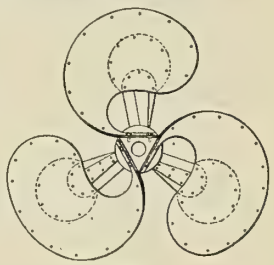
A drag for supporting a sounding instrument, or for a similar purpose, has a box-shaped body having open ends, and openings on all sides.

760. SCREW PROPELLERS. S. L. TAYLOR, FALMOUTH.

The blades of screw propellers are mounted in a hollow boss, and are provided at their inner ends with two pins by which they are reversed. The pins engage a curved slot in a sliding block, operated by a sleeve surrounding the shaft, or by a spindle passing through a hollow shaft. By using two pins, a turning couple is produced when the block is moved.



760.



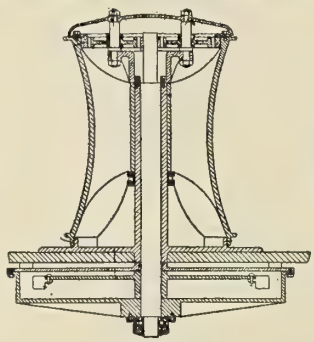
898.

898. SCREW PROPELLERS. D. JONES, CARDIFF.

Relates to screw propellers in which the tips of the blades are continuous and do not overhang the shaft. The blade tips are riveted together, optionally over a bearing-block. The shape of this bearing-block varies with the number of blades used, each blade being built up of juxtaposed sheets. Each sheet constitutes the front surface of one blade and the back surface of the next. The boss in this case is part of a skeleton bracket, to which the roots of the blades are attached by arms. In similar propellers the blades are formed of twin sheets riveted to opposite sides of the flattened portions of arms, which are attached to the boss. The individual blades may, when developed, form a semi-annular or a half-ellipse with a smaller half-ellipse removed.

1,147. CAPSTANS; WINCHES, ETC. E. G. GOSSET-TANNER, AND R. T. DEANE, WESTMINSTER.

Capstans, winches, and like hauling mechanism are driven through reducing gear by a turbine, which is supplied with pressure liquid by means of a pump driven by an internal-combustion engine. A Pelton or like wheel is fixed on a vertical shaft, which is supported on a foot-step bearing. The shaft rotates within a fixed sleeve, and carries at its upper end a pinion which gears with a series of pinions mounted on spindles, carried by the fixed sleeve and supporting a non-rotating cap. The pinions mesh with an internally-toothed ring secured to the inside of the capstan drum, which is supported on ball bearings. A band brake may be arranged to encircle the flanged portion of the drum.



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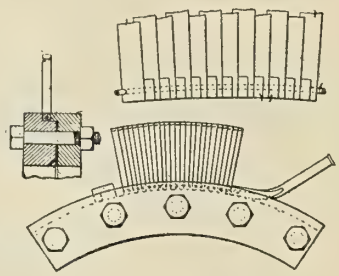

2,381.

2,381. TURBINES. C. A. PARSONS, AND J. W. WILSON, NEWCASTLE-ON-TYNE, AND J. FORD, WALLSEND.

Blades for turbines, turbine compressors, etc., are provided with interlocking means at their roots, so that they can be assembled and calked in a former in ring, segment, or strip form ready for application to the rotor groove. Blades and distance pieces have holes drilled in their centers, through which passes a solid rod or hollow tube. The blades and distance pieces are placed in a groove of a former, and by a suitable calking tool are driven up solidly and tightly, one or more at a time. The groove is slightly narrower than the rotor groove. One side of the groove consists of a removable flange, the width of the groove being determined by distance packing. The calking action causes the wire, blades, and distances pieces to bind together, but the assembled blades may be soldered or otherwise treated for additional security before insertion in the turbine groove.

A Curious Coincidence.—On page 370 of the August number appeared three British patents, all dealing with elastic fluid turbines, and emanating from Switzerland and Germany. The numbers are 27,940, 27,409 and 29,407. It will be noted that the five figures comprising each number are all the same, but differently arranged. The circumstance is, of course, purely accidental.